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### The Foundry Convention at Pittsburgh.

The sixteenth annual convention of the American Foundrymen's Association, held late last month in Pittsburgh jointly with the newer bodies, the American Brass Founders' Association and the Associated Foundry Foremen, illustrated the enormous progress which has been made in the art of iron and steel founding in the past 15 years. According to the viewpoint one may attribute the remarkable growth of the American Foundrymen's Association to the progress in the art, or may attribute a large part of the progress in the art to the association movement. It is really a case of action and reaction. They have grown together, and in observing such results it is immaterial what have been the precise causes, for whatever they may be they are at work and are producing better and better results every year. Certain it is that the free exchange of information which the association movement has brought about has been of inestimable benefit to all connected with the foundry industry.

Not the least important, and perhaps the most important, feature of the foundry convention at Pittsburgh was the colossal exhibit of machinery and materials. Papers can be published and read at any time; they pass through the mails and can be distributed readily. Not so with the machinery which visiting foundrymen were able to see in actual operation.

### Two Causes of Mill Failures.

In the domain of ore treatment the history of large companies is seldom marred by those financial and technical failures that characterize lesser concerns. Expressed in common phraseology, the principal reason for this is that the large companies "go at it right." In other words, they provide adequate capital and employ the best technical skill available. And these two points form the basis of a fundamental lesson.

On the financial side there is a critical period in the early history of a mill, which many small companies do not anticipate and which they are not able to weather—a sort of peak load of financial stress which bears them down to disaster. And the strange feature of it to them is that this period comes when they think they have provided ample funds and should commence to make money. Given a new mill, free from debt and ready to run, it is difficult for them to realize that their troubles have just begun and that very substantial sums frequently must be spent in making alterations and tests before real operations can begin. Thus, while many small companies are able to build and pay for their plants, they have not sufficient money to tide over the critical period of alteration and adaptation which ensues. It is almost safe to say that a small company should have a reserve equal to one-third or one-half the cost of its mill for use in making the plant a real success. Large companies have these experiences to a certain degree, but they are not heard of as failures, because money is available to make them ultimate successes.

In the second instance we may lay down certain axiomatic facts for the guidance of the small concern. First, it is poor economy to "save" the professional fee of a competent metallurgist or engineer when the sum thus involved bears only a small ratio to the total expenditure. Second, excellent business men in other lines do not necessarily make good managers of metallurgical plants, and it is likewise a mistake to put in charge of operations a man whose chief qualifications are that he is a nephew of one of the directors and unemployed. Those who have had experience in such matters know that it pays to be guided by specialists and that many mistakes and perhaps ultimate failure are avoided by employing an engineer who can make a complete study of the situation before a stroke of construction work is done. The whole matter sums up to this: that if adequate financial reserve cannot be supplied and competent professional advice afforded, the venture had better be abandoned before it ends in almost certain failure.

### Experiment and Practice.

A principle in testing metallurgical processes on a small or laboratory scale is that the conditions of the experiment shall comply, as far as possible, with those which will be encountered in actual practice. In every point that the conditions of the test depart far from those of practice there is a possibility of failure, or at least of disappointment, under commercial operation.

In the cyanide process, extraction usually is relative to the degree of fineness to which the ore is ground; the finer the subdivision the better the extraction. But in commercial operation we strike an equilibrium between the cost of grinding and the value of the gold extracted, beyond which it is not profitable to go. At that point finer grinding ceases, and we arrive at the best possible commercial conditions. We have reason to believe that in laboratory experimental work this condition in grinding is neglected to a degree, or rather that the laboratory conditions are not made comparable to commercial conditions, with the result that commercial operation does not come up to the expectations indicated by the tests.

One reason for this is inherent in the different means used for grinding in laboratory and mill. Laboratory grinders usually will produce a greater proportion of undersize of any given mesh than will the commercial machines used in the mill. Hence, if the laboratory tests indicate a suitable extraction when all of the ore is put through a 30-mesh screen, for obvious reasons that standard of excellence scarcely will be attained in practice. By the time a laboratory sample is ground on a bucking board or in a disk grinder so that the whole sample will pass a 30-mesh screen, it probably will contain a greater proportion of, say, the minus 150-mesh size than will be discharged by a Chilean mill fitted with 30-mesh screen. Further, if the ore is of such a nature that the best value is contained in the fine pulp or slime the laboratory test will show a better cyanide extraction than can be obtained in practice, owing to the prohibitive cost of regrinding to equal the laboratory conditions. We believe that a closer control of this tendency toward excessively fine grinding in the laboratory will result in a closer comparison between experimental and practical results.

### Reduction Works as Public Utility Corporations.

Scarcely a biennial session of Western legislatures passes without a spasmodic effort being made to "regulate" the companies engaged in treating custom ore. Some of the proposed legislation has been well meant, but futile, while more of it has been inspired by political motives and without regard to the welfare of metallurgy. Hitherto smelting companies have maintained an active opposition to this sort of activity, at the expense of time and money, and have anticipated the necessity of combating adverse legislation with each recurring biennial period.

The latest attempt to control ore reduction is the passage of a bill by the Colorado Legislature submitting to the people a constitutional amendment which, if adopted, declares all smelters, mills, reduction plants, and ore-treatment works of all kinds to be public-utility corporations, and, as such, amenable to legislative regulation and control as regards the tariff charged for their work. Aside from being poorly drawn as to exact wording and meaning, and leaving out of consideration the fact that the people of Colorado will scarcely adopt the amendment, the bill possesses certain potential features which are undesirable.

If the amendment should be adopted, future Legislatures would be empowered to regulate ore-treatment rates. In the smelting business particularly this is a technical matter, owing to the necessity of having the proper variety and quantity of ores to make suitable smelting mixtures. In chlorination and cyanidation it is frequently necessary to discriminate in favor of clean ores and against those containing an undesirable element or substance. In all ore treatment the gross value of an ore affects treatment rates and recoveries.

Considering these things it will be apparent how difficult it would be to regulate rates for ore treatment, save through the medium of a board of experts who would have to be as competent technically and as well-informed commercially as the custom companies themselves. In other words, in order to act competently such a board would have to be in possession of all the professional and business knowledge of the companies, and this is obviously impossible. Further it would be incumbent on such a board to reconcile the differences of mining companies in different districts, producing ores of diverse metallurgical character and justly subject them to discriminating rates of treatment. If it is not clear now that the entire procedure would result in a hopeless tangle, the fact will be appreciated when the attempt is made to put the law into effect.

The mere adoption of the amendment, however, would be a menace to metallurgical progress even though future Legislatures did not use their powers and try to regulate rates. New companies contemplating entering Colorado would hesitate about engaging in an industry over which hung a possibility of disturbance and interference.

Perhaps those against whom the bill was directed realized the futility of the whole scheme, for no obstacle was placed in the way of the bill's passage. Should its provisions finally come into full effect, it is difficult to say what would be the action of the principal smelting companies. Instances have been known where companies have seized on a suitable pretext to quit business altogether and abandon plants, and as the smelting industry in Colorado is in none too good condition it might be fur-

ther hampered by the abandonment of plants. Granting that metallurgical companies need regulation in Colorado, the cause will hardly be improved by the present effort.

### Efficiencies in Electrochemistry

We believe it was Mr. James Swinburne who once remarked that efficiency is a byword of politicians and that when engineers use the term they should speak of efficiencies rather than efficiency. It may not be out of place to give here a concise sketch of the almost bewildering variety of efficiencies with which we have to deal even in such a restricted field as electrochemistry. The subject is of timely interest in view of the discussion, or, rather, repeated discussions, at the recent convention of the American Electrochemical Society, where besides various shades of intermediate opinions two extreme views found expression—one to the effect that a manager of a works does not know what he is doing except he can state the efficiency of operation in per cents, the other to the effect that in most cases of practice efficiency is so vaguely defined that it means nothing and that the term should not be used at all.

In any case, when we speak of an efficiency we compare a figure obtained in practice with a theoretical figure corresponding to ideal conditions. In electrolytic processes we may compare the quantity of material reduced at the cathode or oxidized at the anode in practice with the quantity which should be reduced or oxidized according to Faraday's law under ideal conditions. Faraday's law is always exactly fulfilled. "Under ideal conditions" means, therefore, such conditions that only the one desired reaction and nothing else occurs at the cathode or anode. For instance, according to Faraday's law, every 1000 ampere hours deposit from the solution of a bivalent copper salt 1.2 kilogram of copper if this is the only cathodic reaction. If in practice we get only 0.9 kilogram of copper, we say the cathodic amperehour efficiency is 75 per cent. This means that the balance of 25 per cent. of ampere hours are consumed to produce some other reaction that is not wanted and are therefore wasted. The figure of amperehour efficiency has therefore a distinct well-defined practical meaning; it states to what degree the one reaction which we desire to obtain really goes on. But even here we should distinguish between two efficiencies, the anodic and cathodic amperehour efficiencies, since there is no reason why both should have the same value.

However, of more direct practical bearing is the watt-hour efficiency, since not the amperehours, but the watt-hours, are paid for. In this case we, therefore, should give the energy given out in practice by a galvanic cell or the energy consumed in practice by an electrolytic cell in per cents of the energy given out or required according to theory under ideal conditions. A galvanic cell works "under ideal conditions" when the whole available energy is changed into electrical energy (that is, if there is no local action, if the Joulean heat developed is negligible, etc.). But what is the "whole available energy"? In practice it is customary to use simply the reaction heat. This is absolutely wrong in principle. The available energy is the "free energy of reaction," not the reaction heat, to be correct in principle. This subject was discussed at some length in an editorial on page 2 of our Vol. II in connection with a paper by Prof. Lorenz (Vol. II, p. 15); hence there is no necessity to discuss it here further than by pointing

out one example. This is the rather rare case that an endothermic process may be used for the generation of electrical energy in a battery. In one example referred to in Prof. Lorenz's paper a cell, according to Thomson's rule, should require the expenditure of 0.14 volt to be impressed from the outside, while in reality it gives out spontaneously an e.m.f. of 0.32 volt; when the reaction goes on at constant temperature heat is supplied from the surroundings to the system, and this heat is partly used up in supplying the heat of the chemical reaction and partly changed into electrical energy. It would clearly be foolish to define watt-hour efficiency in such a case on the basis of taking the heat of the reaction as available energy. This whole question is intimately connected with the question of Thomson's rule versus the Gibbs-Helmholtz equation. The latter is the correct one in principle. Nevertheless the former is mostly used and is, in the majority of cases, a good enough approximation for practical purposes. In an analogous way we may continue to use the old watt-hour efficiency, employing the reaction heat as basis of calculation, if we always remember that it is only an approximation and that in some cases it may lead into unsurmountable difficulties.

However, industrial electrochemistry is a much broader field than the restricted one which we have discussed so far. It includes all electric-furnace processes, whether they involve any chemical reaction or not. Further, industrial processes are in general not constant-temperature processes, as has been silently assumed in the preceding paragraphs. It is, therefore, important, as Dr. J. W. Richards pointed out at the meeting of the American Electrochemical Society, to distinguish two things: First, the process involving a temperature change, like the melting of a cold charge; and, second, the process of keeping a molten charge at a constant temperature. In the first place an exact definition of efficiency is possible; to calculate it numerically, it is necessary to know or to assume specific heats, latent heats of fusion and perhaps vaporization, and also to take into account any chemical reactions which occur.

On the other hand, in the second case—where a molten charge is kept at a constant temperature—it seems impossible to give in an analogous way a useful definition of efficiency, simply because the ideal condition in this case is that there is no energy required (assuming that the charge is allowed to "rest" and that no chemical reaction takes place). Hence, on the basis of comparison with an ideal furnace, all real furnaces are alike in having zero efficiency in this respect. What is possible, however, is to compare real furnaces among themselves by stating, for instance, that different furnaces, otherwise alike, require so and so many kw-hours per ton of charge to maintain their temperature constant. As Mr. Lidbury pointed out at the meeting, such comparative figures are all that is needed and there is no need of speaking of efficiency at all. What such a figure represents is strictly specific power consumption, not efficiency. But if people want to call it an efficiency we do not see how they can be prevented. The jargon of the engineer cares very little for the rules of the philologist and logician. This much, however, must be insisted upon: That when an efficiency figure is given it should be accompanied by an exact definition of what is meant and by a statement of the assumptions made and of the figures used in the calculation.



### American Institute of Chemical Engineers.

The summer meeting of the American Institute of Chemical Engineers will be held at Chicago from June 21 to 24. All the sessions will be held at the Congress Hotel.

Dr. Frerichs will present his presidential address on methods of attacking chemical industrial problems. Dr. S. P. Sadtler will present the report of the committee on chemical engineering education.

The program of papers is as follows:

Wednesday, June 21, 11 a. m.:

Report of committee on chemical engineering education.

By Dr. Sam. P. Sadtler, chairman.

The four-year chemical engineering course. By Prof. J. H. James.

Wednesday, 8 p. m.:

Presidential address by Dr. Frerichs.

Friday, 9:30 a. m.:

Industrial chemical calculations. By Prof. J. W. Richards.  
Rapid determination of tin in food products. By Dr. Edw. Gudeman.

Distillation on the continuous system. By Chas. L. Campbell.

A new system of lead and silver lining for chemical apparatus. By Chas. L. Campbell.

The Institute and the United States patent system. By Dr. Wm. M. Grosvenor.

Friday, 7:30 p. m.

Manufacture of gelatine. By Ludwig A. Thiele.

The practical value of calorific tests on anthracite coal. By S. F. Peckham.

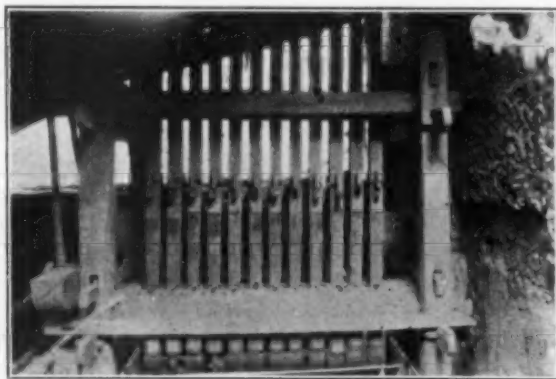
Two methods of testing asphalt. By S. F. Peckham.

A large number of interesting excursions has been arranged for the afternoons of Wednesday and Friday, and for the whole days of Thursday and Saturday. These include the plant of Swift & Company at Union Stock Yards, the Corn Products Refining Company at Argo, Ill., the laboratories of Dearborn Drug & Chemical Works, the By-Products Coke Corporation at South Deering, the Carter White Lead Company at West Pullman, the Indiana Steel Company at Gary, Ind., the Universal Portland Cement Company at Buffington, Ind., the Illinois Steel Company at South Chicago, and the Standard Oil Refinery at Whitney, Ind.

Dr. J. C. Olsen, Polytechnic Institute, Brooklyn, is the secretary of the Institute.

### Old Mexican Stamp Mill.

The accompanying illustration is interesting as showing the primitive practice of the Mexicans in stamp milling gold ore.



OLD STAMP MILL AT TEZICAPAN, GUERRERO, MEXICO.

The photograph was taken at Tezicapan, Guerrero, Mexico, by Mr. George J. Hough, and shows twelve stamps of wooden stems and iron heads. The stems are about five inches square,

and the heads of cast iron are about the same dimensions in cross section and twelve inches long. One of the stamps in the illustration is shown detached from the stem, into which it was the practice to insert it with wedges. The cam shaft was a large, round timber with spikes or stems driven into it. As the shaft revolved these stems engaged the keys on the stamp stems and raised the stamps a short distance. Perforated cowhide was used as a screen, and portions of hide tanned with the hair on were to be found in a good state of preservation near the mill.

### The Western Metallurgical Field.

#### Metallurgical Education.

Diversity of opinion exists as to the best methods of teaching metallurgical processes to students in our schools of mining and metallurgy, particularly with reference to the equipment and apparatus used. On the one hand we find a tendency to favor work on a large scale with standard size apparatus and machinery; and on the other a preference for small operations with well-designed models of the standard machines. The first idea is finding expression at home and abroad in the Imperial College of Science and Technology, South Kensington, London, and at the Colorado School of Mines, Golden. At each of these schools there is being installed a metallurgical laboratory and testing plant which compares in size and equipment with many mills built for commercial operation. The machines are standard size and the operations are conducted with tons of ore instead of pounds. The sponsors of this method of teaching are enthusiastic in their belief that it is the best for students, as it gives them opportunity to handle standard machines in a commercial way. They believe that the student can become familiar with principles by applying them in practice.

The other method has been far more extensive, for obvious reasons of expense of installation and cost of securing quantities of ore to work on, and perhaps those who advocate the new method regard the old as less efficient. Nevertheless, there is much to be said in favor of small operations for purposes of instruction. It has been the method pursued at the Massachusetts Institute of Technology, and as this school has acquired a reputation for the way in which its teaching work is done it may be well to consider the reasons which underlie the methods used there. The following is taken from recent correspondence on the subject:

The question of large versus small machines for teaching students in the laboratory is largely a question of the ability of the machines themselves. If the machines are well adapted and perfectly made the small machine can teach jiggling and table work and small plant work just as well as the large machine. At the Institute of Technology the only large-size machine used is the vanner, and this has a width of 4 ft. instead of 6 ft., as is now common.

The question of size of machine seems to be partly a personal matter with the teacher, who may prefer large-size machines to small ones, and partly a question of locality. If ores can be had and given to the school by miners the large-size machines might be preferable, but where ores have to be brought a long way the small machine serves perfectly.

There are two other questions which come up in connection with settling this matter. One is the feeling of the profession of the neighborhood of the school, as to whether they are of the opinion that it is necessary to have large machines. If the public opinion says that the school must have large-size machines, then it must be so or the school will lose caste. The other is the question of testing ores for mines. If a school is located in a mining district it is pretty certain to have ores sent to it with the idea that the results of the tests shall be given to the owners of the ore, either for a small fee or as a return for the favor done in sending the ore, so that the mine may profit by the test, while the school profits by having the ore to work on.



It is the opinion at the Institute that if small machines are carefully designed there, they will do work that will rank with the very best large-scale machines ever made. It is further believed that the students working on small-size machines can do their preliminary illustrative work when they are learning what the machines are, at the same time they are listening to the lectures, and that this can be done just as well on small machines as on large. Finally, students can do just as careful testing work for their theses on small machines, and possibly better work, than they can on large.

The argument may be summed up by saying that if public opinion, which controls matters in the school, favors large machines, and if it will not ruin the treasury to buy these machines and pay for large quantities of ore to run them, then it may be best to buy them. If, on the other hand, public opinion in regard to this matter prefers leaving the selection to the teachers in charge, and if the cost of ore is a serious item, then the small machines would be selected by those in charge at the Institute.

On the score of ore tests, it is believed that it is a matter of extreme value to a mining company to have a lot of ore tested carefully on small-scale machines which have been carefully designed and properly run. From the results so obtained the company can get figures which will serve as a standard of perfection for them to try to attain on their large-scale operations; and if they attain the perfection which it is believed can be shown on well-designed small machines, they can feel satisfied that they have done the best that can be done according to the plan followed.

#### The Bureau of Mines and Metal Mining.

For various logical reasons the first work of the national Bureau of Mines has been in connection with the coal-mining interests. At the last session of Congress an effort was made to secure an appropriation for work in connection with metal mining, and \$50,000 was set aside for such work as should be decided upon. It appears probable that this sum will be expended on the establishment of a western laboratory for investigations in metallurgy. Report has it that the laboratory will be located at San Francisco, and that its first work will be in the nature of conservation in metallurgical processes. Such problems as the prevention of smoke and fume loss, perfection of processes to minimize tailings losses, investigation of promising new fields of metallurgy and electrometallurgy, etc., probably will occupy the attention of this first laboratory. Prof. Frederick G. Cottrell, of the University of California, has been mentioned as the chief of the new laboratory, and judging from his former success as an investigator in metallurgical and chemical engineering the choice would be a good one.

Press comments are confused as to the function of a government laboratory, and some notion exists that it will be a free assay office and general information bureau. Certainly this is a trivial view to take of the matter. The mining industry has hitherto expended vast sums in overcoming obstacles in ore treatment and in investigating matters which promised uncertain returns. The effect has been good but of limited usefulness; because, being privately obtained, the information also was privately held. Again, many companies have duplicated work along certain lines, because each had to gain its own information or drop behind. Finally, much of the progress has been made by large companies, and is applicable only to large-scale operations and of little value to a small operator.

Thus the industry has progressed because some companies were rich enough to spend sums in investigation which is denied the larger part of the operators. It is believed that government laboratories can undertake many lines of investigation which will obviate some of the objections just raised and which will result in a general dissemination of information that will benefit the entire metallurgical industry.

#### Missouri Zinc Fields.

The unsettled state of affairs in Mexico has had the effect

of sending more buyers into the zinc districts of Missouri, resulting in improvement in market conditions owing to greater competition. Additional interest in this district arises from the large operations of the American Zinc, Lead and Smelting Co., which is one of the largest factors in the field. Several weeks ago this company acquired under lease and bond 640 acres of land in the sheet-ground district near Webb City.

Following the policy of mining and milling its own ores, the company plans to erect a mill of over a thousand tons daily capacity, which will be the largest in the district. It is said that the mill will be patterned after the one owned by the same company at Plattsville, Wis., where the Huff electrostatic separators are in use. Among the other reported activities of this company is the erection of a new zinc smelter at Collinsville, Ill.

#### International Smelter, Utah.

The Tooele plant of the International Smelting & Refining Co., originally built and started as a copper smelter, is to be enlarged by the addition of two lead furnaces of a combined daily capacity of 500 tons. This is a part of the original plan of the company, although it was not known when the mining situation would warrant the starting of a new lead smelter in Utah. The company has been buying lead ores for some time, and a large tonnage is now on hand, which will provide at least six months' supply when the furnaces are ready.

This places the International company in competition with the American Smelting & Refining Co. and the U. S. Smelting Co., as regards lead ores as well as copper. The former operates a lead plant at Murray and a copper plant at Garfield, while the latter has both lead and copper smelters at Midvale. Apparently the general ore situation in Utah is improving, and with active competition on the part of three large corporations there should ensue a period of prosperity for the entire industry. In this respect Utah has an advantage over Colorado, which, in the height of its mining activity, had only one company bidding for smelting ores.

#### The Non-Ferrous Metal Market.

Dullness has characterized the market for all non-ferrous metals since our last report. Business has been so low in some cases that quotations are but nominal, and such business as has been transacted has been at shaded prices.

**Copper.**—Consumers are pursuing a policy of buying for immediate needs only, and the general belief is that most of them are not as well covered as good business policy would dictate. With a rise in prices there will undoubtedly be heavy purchases, especially if the upward tendency should appear permanent. Lake copper is quoted at 12½ cents to 12¾ cents and electrolytic at 11.9 cents to 12 cents.

**Lead.**—The market is very dull and there has been a lower tendency in prices. The St. Louis market quotes lead at 4.22½ cents to 4.25 cents, and New York at 4.37½ cents to 4.40 cents.

**Spelter.**—Business has been negotiated at figures below the quotations, and the market has shown a tendency to go lower. Even though the supplies of spelter are required for work in this country, manufacturers show no disposition to buy heavily at present prices. St. Louis spelter is quoted at 5.20 cents to 5.22½ cents, and New York at 5.35 cents to 5.37½ cents.

**Tin.**—The market has been unusually quiet, and consumers can provide for their needs at figures below the import basis. The quotation for May tin in New York was nominally 42 cents.

**Other Metals.**—Aluminium prices are unchanged at 20½ cents to 21 cents per pound for No. 1 ingots. Antimony has moved slowly, and the prices range from 8 cents to 9.6 cents for various grades. Quicksilver has been steady at \$46.50 per flask of 75 lb. in New York and \$46 in San Francisco.

### The Iron and Steel Market.

As this report is written the price structure in the finished rule a day or a week hence. On May 24 the Republic Iron & Steel Company began openly to sell steel bars at 1.25 cents, Pittsburgh, the recognized market having been 1.40 cents. It formally announced its abandonment of the policy of co-operation with other manufacturers in the matter of steel bar prices, directing attention to the impracticability of maintaining the 1.40-cent basis on soft steel bars when iron bars and hard steel bars rolled from old rails were being sold at prices so much lower, and intimating that there had been irregularities on the part of some other producers of soft steel bars.

Iron bars have sold as low as 1.20 cents, Chicago, while the 1.40-cent price on steel bars has meant 1.58 cents, Chicago. Bars rolled from old rails have sold at from 1.20 cents to 1.25 cents at various mills in the central West, and it has been quite obvious that the 1.40-cent, Pittsburgh, price on soft steel bars has been out of line.

Ultimately the break in the steel bar price is likely to lead to a general revision of prices of semi-finished and finished steel, but the readjustment may perhaps proceed slowly. In some respects the condition resembles that in February, 1909, when a general and rapid decline commenced, and in other respects the condition is quite different. In the previous instance there was a definite understanding among a number of producers that the entire steel market, outside of steel rails, should be opened; in the present instance the move is taken by a single independent steel interest, which does not make a full line of product. It is one of the heaviest producers of steel bars and is also prominent as a seller of billets and sheet bars, as well as of railroad spikes, but plates, shapes and wire products it does not make, while it has only lately commenced the manufacture of pipe.

The last week in April and the first three weeks in May constituted the dulllest period in the booking of orders for finished steel products which the trade has seen for a very long time. The market seemed to be seized with an almost complete paralysis, the meager tonnage booked being far below any reasonable estimate of the minimum current requirements of the country. From this situation an improvement could not but result, and before the first break in steel prices there were signs of a slight improvement. The Pennsylvania Railroad System, which on April 1 issued general orders to discontinue shipments of rails and track supplies, rescinded the orders and began receiving material again. Several other roads which had issued somewhat similar orders began to take increased shipments, and some new buying began to appear.

By common consent the iron and steel trade has concluded that the second half of this year will be a large one from a tonnage standpoint, although at no time have prospects been that even fairly high prices would be realized. With a long period of liquidation in stocks after the unhealthy boom of the late months of 1909 the country has found itself bare of material in the hands of mills, jobbers and manufacturing consumers. Financial conditions are good and the country has had four years of growth since the last period when the capacity was fully employed.

#### Pig Iron.

The Southern pig-iron market dropped 50 cents a ton early in May as to deliveries in the second half, and fairly large sales were made for delivery to the end of the year on the basis of \$10.50, Birmingham. There are predictions that this figure will prove the turning point after the long decline, which began in October, 1909, after the sharp rise just preceding. In the East basic iron sold down to \$14.50, delivered Philadelphia district. In the Central West basic iron declined on practically each sale made, until \$14, delivered Pittsburgh, or \$13.10, valley, was done without much difficulty. Foundry iron has remained nominally at \$13.75, valley, but buyers have no confidence in the market and pursue a strictly waiting policy. The Bessemer iron is held nominally at \$15, valley, but a few odd lots have

been sold by brokers at concessions of from 15 cents to 25 cents.

#### Production.

Production of pig iron and finished steel has declined steadily since about April 1. Pig iron is being made at the rate of between 21,000,000 tons and 22,000,000 tons a year, against a rate of 26,000,000 tons on April 1. In March finished steel was being made at the rate of about 75 per cent of total capacity, but at the close of May steel works operations do not average over about 50 per cent, and the decrease may continue through June. The almost universal expectation, however, is that the turning point will be reached by midsummer.

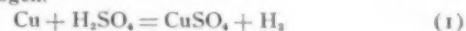
### CORRESPONDENCE.

#### Generating Electricity from Heat.

To the Editor of Metallurgical and Chemical Engineering:

SIR:—The writer desires to point out a new possibility for converting heat into electricity by way of the primary battery.

It is generally known that some metals like copper and silver are decomposed by hot sulphuric acid with evolution of sulphurous acid. The latter is, however, the result of a secondary reaction and due to the reduction of the hot sulphuric acid by nascent hydrogen.



Hence there is no material difference between the reactions of copper and zinc with sulphuric acid. The greater affinity of zinc for the acid sufficiently accounts for the fact that here the hydrogen is liberated at ordinary temperature, while in the case of copper a stronger acid and a higher temperature are required. By amalgamating the surface of a piece of zinc the evolution of hydrogen is much diminished; in other words, its chemical action on sulphuric acid is weaker, yet the faculty of the zinc to send its ions into solution is even greater when alloyed with mercury.

By raising the temperature of sulphuric acid in which a piece of copper is immersed we increase its tendency to pass into the ionic state, and it is probable that the electric pressure will rise more or less proportionately with the increment of temperature up to the moment when the  $\text{SO}_2$  gas is liberated, it being then a maximum.

For the present it will be sufficient to indicate that there exists an e.m.f. between copper and sulphuric acid at a temperature somewhat below that at which  $\text{SO}_2$  would be set free. To make this e.m.f. available for practical purposes we must avail ourselves of another electrode which is surrounded by a suitable depolarizer and the latter should be prevented from freely intermixing with the sulphuric acid. By fulfilling these requirements we create a modification of the Daniell battery.

Using like Daniell a solution of sulphate of copper as depolarizer in which a copper cathode is immersed, and using instead of the zinc an electrode of copper surrounded by hot sulphuric acid, we have as an interesting feature a battery with electrodes of the same material.

Since the hot electrode will always dissolve while the cold one will receive the deposition of metal from the hot one it is evident that the migration of the ions will gradually cause an accumulation of  $\text{CuSO}_4$  about the dissolving copper anode and of free  $\text{H}_2\text{SO}_4$  about the copper cathode upon which copper is deposited.

These conditions bring about a decline of the available voltage of the cell and in order to restore it to the original intensity it is now necessary to heat the compartment which before was kept cool and vice versa. An interchange of the hot and cold solutions by convection currents must be prevented, of course.

Since the cycle of reactions is complete the sole agent for the electric energy produced by this cell is the inequality of temperature prevailing at its electrodes.

Waterbury, Conn.

R. V. HEUSER.



### Comparative Grinding Experiments with a Chilean Mill and a High-Speed Roll at the Detroit Copper Company's Concentrator, Morenci, Ariz.

BY RUDOLF GAHL, PH.D.

Several interesting articles have been published recently describing experiments carried out to establish the most economical method of crushing and grinding ore. Most of these experiments, as for instance those undertaken by Mr. Caldecott, deal particularly with the reduction of ores preliminary to cyanide treatment. Very few experimental data are available referring to the reduction of ore preliminary to concentration.

Some tests were made several years ago at this plant by Mr. Frank Probert, with the idea of determining whether Chilean mills or high-speed rolls are more suitable for grinding in concentrating plants, and his results were published.\*

More recently the installation of Chilean mills by the Utah Copper Company has been made the subject of very severe criticism. In this connection the following experiments may be of interest which are essentially a very careful repetition of Mr. Probert's tests and were carried out in the course of the past year.

The Chilean mill used in these tests was a 5-ft. Monadnock mill made by the Trent E. & M. Company running at a speed of 36 r.p.m. The rolls made by the Gates Iron Works have a width of 15 in., a diameter of 36 in., and are operated at 140 r.p.m. The product of the rolls was in the first test screened by a shaking screen operated by a Wilfley motion, in the later tests by a trommel. The oversize was fed to an elevator and returned to the rolls. Operated in this manner the rolls made only one product, viz., the undersize of the screen, which could be compared to the product as discharged by the Chilean mill.

This undersize was carefully sampled for a number of days. Of a composite sample representing an average of the days over which the sampling was extended a careful screen analysis was made.

**Test No. 1.**—Feed: Tailings from jigs working on a trommel product, passing through 7 mm and remaining on 5 mm trommels.

Screens:  $2\frac{1}{2}$  mm round hole screens on Chilean mill, and on shaking screen screening roll discharge.

Average load: 109 tons per machine per day.

Oversize from shaking screen: 9.3 per cent of feed.

The results of screening the mill discharge and the roll screen undersize are tabulated in Table No. 1 and represented graphically in Fig. 1. The conclusions to be drawn from these figures are that when the same screen cloth is used on a Chilean mill and on the screen which screens the roll discharge the rolls produce very much less slime than the mills.

TABLE I.

	Rolls.	Mills.
0-20.....	23.10	11.00
20-30.....	16.00	7.00
30-100.....	23.40	21.20
100-200.....	6.60	9.30
200-∞.....	30.90	51.50
	100.00	100.00

The object of the following test was to determine whether the same difference in the sliming of the rolls and mills exists also when a finer material is reground.

**Test No. 2.**—Feed: Tailings from jigs working on a trommel product, passing through 5 mm and remaining on  $2\frac{1}{2}$  mm trommels.

Screens:  $2\frac{1}{2}$  mm round hole screens on Chilean mill, and of shaking screen, screening roll discharge.

Average load: 65.7 tons per machine per day.

Oversize from shaking screen: 6.0 per cent of feed.

\*Eng. & Min. Jour., Vol. LXXIX, 1905, p. 1089.

The results of screening the mill discharge and the roll screen undersize are tabulated in Table 2 and represented graphically in Fig. 2. (p. 294). The same conclusion may be drawn from these figures as those from test No. 1, that when the same screen is used for rolls and mills the rolls produce very much less slime than the mills.

The same result has been obtained by other experimenters and the conclusion been drawn that, inasmuch as the size of the maximum grains was the same for both machines, and the quantity of the undesirable slime so much smaller for the rolls, they were better suited for this class of work. In drawing this conclusion it has been taken for granted that the economic

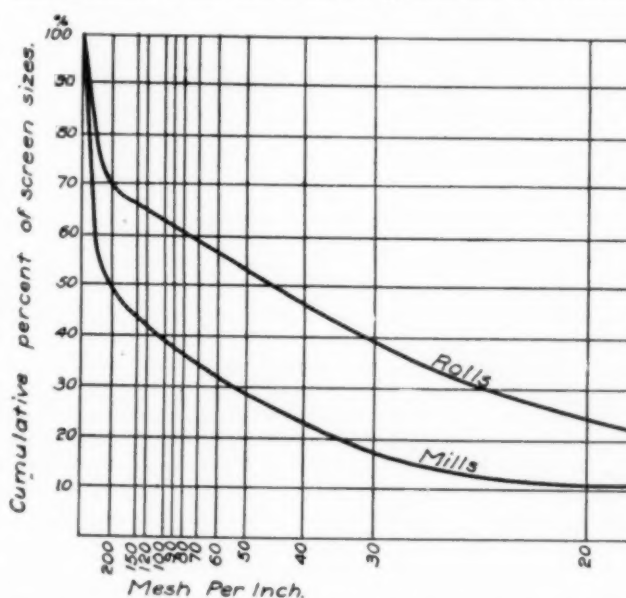


FIG. 1.—GRAPHICAL REPRESENTATION OF SCREENING RESULTS OF TABLE I.

mineral has been liberated equally well by the rolls as by the mills.

In order to determine whether this assumption is justified the different screen sizes were concentrated on a small experimental Wilfley table, with the exception of the material passing through 200 mesh. The amount of concentrates that could be expected to be saved from this slime was determined by panning. The results are also represented in Table 3 (p. 294).

It will be noticed that while a large amount of copper is lost by the mill in the form of slime, the sand tailings originating from the rolls contain more copper than the corresponding material from the mill. This accounts for the fact that actually more copper could be saved from the mill product than from the roll product.

The object of the following test was to make the same comparison as had been made in the preceding test for  $2\frac{1}{2}$ -mm screens, with finer screens on the machines.

**Test No. 3.**—Feed: Tailings from jigs working on a trommel product, passing through 5-mm and remaining on  $2\frac{1}{2}$ -mm trommels.

Screens: One-mm round-hole screens on Chilean mill; 14-mesh No. 19 wire (opening, 0.79 mm) on trommel screening roll discharge.

Average Load: 48.8 tons per machine per day.

Oversize from Trommel: 21.8 per cent of feed. (This is equivalent to the statement that 68.6 per cent of the roll discharge is constantly returned. The high percentage of oversize returned is partly due to the fact that owing to the heavy load of fresh feed and returning oversize the trommel was heavily overloaded and its screening action very imperfect, which is shown by a screen analysis of the oversize tabulated in table 3.)

The results of screening the mill discharge and the roll



TABLE II.—ROLLS.

	CONCENTRATES.			MIDDINGS.			TAILINGS.			TOTAL.			
	Weight.	Assay.	Cu.	Weight.	Assay.	Cu.	Weight.	Assay.	Cu.	Weight.	Assay.	Cu. Direct.	Cu. Calculated.
0-20.....	0.14	8.02	1.1	0.23	1.75	0.4	9.85	0.59	5.8	10.22	.76	7.8	7.3
20-30.....	0.37	7.19	2.7	0.18	1.86	0.3	15.52	0.56	8.7	16.07	.73	12.7	11.7
30-100.....	1.59	7.81	12.4	0.71	3.86	2.7	21.92	0.39	8.5	24.22	1.03	25.0	23.6
100-200.....	0.86	11.04	9.5	0.80	0.40	0.3	5.64	0.23	1.3	7.30	1.50	10.9	11.1
200-∞.....	1.15	15.86	18.2	4.14	0.34	1.4	36.90	0.54	19.9	42.19	0.94	39.7	39.5
	4.11	10.69	43.9	6.06	0.84	5.1	89.83	0.49	44.2	100.00	0.96	96.1	93.2

MILLS.

	CONCENTRATES.			MIDDINGS.			TAILINGS.			TOTAL.			
	Weight.	Assay.	Cu.	Weight.	Assay.	Cu.	Weight.	Assay.	Cu.	Weight.	Assay.	Cu. Direct.	Cu. Calculated.
0-20.....	0.07	3.42	0.2	0.08	1.36	1.1	6.35	0.41	2.6	6.50	.48	3.1	3.9
20-30.....	0.10	5.30	0.5	0.21	1.46	0.3	5.89	0.40	2.4	6.20	.48	3.0	3.2
30-100.....	1.54	6.37	9.8	0.68	1.03	0.7	18.19	0.28	5.1	20.41	.78	15.9	15.6
100-200.....	0.98	10.45	10.2	0.45	0.64	0.3	8.19	0.24	2.0	9.62	1.26	12.1	12.5
200-∞.....	1.73	16.48	28.5	3.44	0.42	1.4	52.10	0.57	29.7	57.27	1.06	60.7	59.5
	4.42	11.12	49.2	4.86	0.78	3.8	90.72	0.49	41.8	100.00	0.95	94.8	94.7

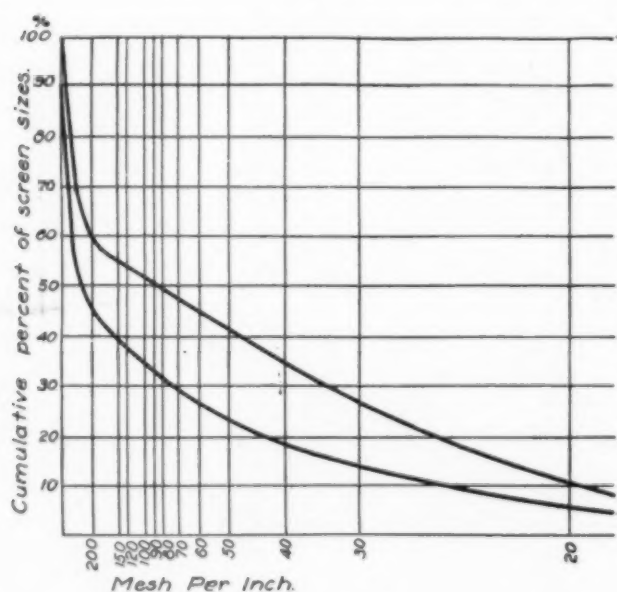


FIG. 2.—GRAPHICAL REPRESENTATION OF SCREENING RESULTS OF TABLE II.

screen undersize are tabulated in Table 4 and represented graphically in Fig. 3.

The result is practically a standoff between rolls and mills, the rolls losing more copper in the sands and the mills more copper in the slimes.

It appears, therefore, that the same saving of copper can be obtained by grinding in Chilean mills as by grinding in rolls, and that in a much simpler way mechanically. Reliable comparative operating costs are not available, but it seems reasonable to assume that on account of their simplicity the larger sizes of mills should be cheaper in operation than rolls, count-

TABLE III.

Trommel.	Overize.
0-10.....	16.0
10-20.....	24.2
20-30.....	34.9
30-50.....	14.2
50-100.....	7.2
100-200.....	0.8
200-∞.....	2.7
	100.0

ing in the auxiliary screening and elevating machines. Elevating can, of course, be avoided by sending the overize to other grinding machines.

The conclusion drawn from the previous tests, that the same saving in copper can be obtained from ore ground in Chilean mills as from ore ground in high-speed rolls, holds true, how-

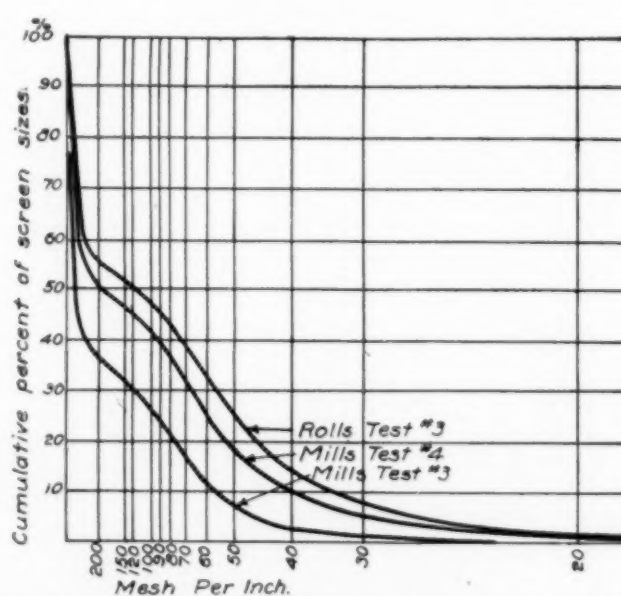


FIG. 3.—GRAPHICAL REPRESENTATION OF SCREENING RESULTS OF TABLES IV AND V.

ever, only for the case that the grinding in these machines is final and is not followed by regrinding of any part of the pulp. Where the coarse part of the pulp is reground rolls are evidently preferable, as their product contains considerable amounts of copper mineral in the sands from which it can be set free by regrinding.

It was tried in the following test to decide if this point of superiority is really due to the characteristic grinding action of the rolls or more to the fact that the ore is not ground in one step to the desired fineness, but in stages, grinding alternating with screening. If the latter is the case, the same object should be attainable by Chilean mills using a coarse screen (or possibly no screen at all) on the mill itself, and a finer screen not connected with the mill, in addition, which would make the separation between overize (to be returned) and undersize (to go to the concentrating machines).

**Test No. 4.—Feed:** Tailings from jigs working on a trommel product passing through 5 mm and remaining on 2½ mm. Screens: 3 mm (slotted) on Chilean mill. The Chilean mill product passed to a trommel with 14-mesh No. 19 wire (opening, .79 mm), the overize of which was returned to mill.

**Average Load:** 70.3 tons per machine per day.

**Overize from Trommel:** 58.7 per cent of feed. (This is equivalent to the statement that 37 per cent of the mill discharge is constantly returned.)

The results of screening the mill discharge are tabulated in

TABLE IV.—ROLLS.

	CONCENTRATES.			MIDDINGS.			TAILINGS.			TOTAL.			
	Weight.	Assay.	Cu.	Weight.	Assay.	Cu.	Weight.	Assay.	Cu.	Weight.	Assay.	Cu. Direct.	Cu. Calculated.
0-20.....	.....	.....	.....	.....	.....	.....	0.88	1.36	1.2	0.88	1.36	1.2	1.2
20-30.....	0.12	12.86	1.5	0.16	4.50	0.7	7.25	0.86	6.2	7.53	1.10	8.3	8.4
30-50.....	0.65	13.15	8.5	0.69	3.51	2.4	14.99	0.71	10.6	16.33	1.25	20.4	21.5
50-100.....	2.05	14.75	30.2	1.74	2.47	4.3	18.78	0.45	8.5	22.51	1.92	43.4	43.0
100-200.....	0.75	21.32	16.0	0.80	1.72	1.4	6.59	0.33	2.2	8.14	2.47	20.1	19.6
200-∞.....	1.85	19.66	36.4	.....	.....	sand slime	19.20 23.50	0.44 0.76	8.4 17.9	44.55	1.39	62.0	62.7
	5.42	17.08	92.6	3.39	2.60	8.8	91.19	0.60	55.0	100.00	1.55	155.4	156.4

MILLS.													
	CONCENTRATES.			MIDDINGS.			TAILINGS.			TOTAL.			
	Weight.	Assay.	Cu.	Weight.	Assay.	Cu.	Weight.	Assay.	Cu.	Weight.	Assay.	Cu. Direct.	Cu. Calculated.
0-20.....	.....	.....	.....	.....	.....	.....	1.21	0.76	0.9	.....	.....	.....	.....
20-30.....	.....	.....	.....	.....	.....	.....	5.34	0.44	2.3	1.21	0.76	0.9	0.9
30-50.....	0.23	6.55	1.5	0.22	2.85	0.6	16.88	0.36	6.1	5.79	0.80	4.6	4.4
50-100.....	1.45	12.33	17.9	1.56	2.48	3.9	7.19	0.32	2.3	19.89	1.39	27.6	27.9
100-200.....	1.01	17.62	17.8	1.64	0.84	1.4	28.98	0.46	13.3	9.84	2.19	21.5	21.5
200-∞.....	2.61	22.38	58.4	.....	.....	sand slime	31.68	0.99	31.4	63.27	1.60	101.2	103.1
	5.30	17.47	92.6	3.42	1.73	5.9	91.28	0.62	56.3	100.00	1.56	155.8	157.8

Table 5, and represented graphically in Fig. 3, together with the results of test No. 3.

The curve representing this mode of operating a mill in Table No. 7 (corresponding to the return of 40.6 per cent of mill discharge) approximates the curve obtained for the rolls when the product was screened on the same screen (with an oversize return of 68.5 per cent of the roll discharge). It seems to be safe to assume that for the same percentage of oversize the curve for the mill will reach the curve for the rolls.

It follows, therefore, that the rolls have not any inherent advantage over mills for grinding fine. It has to be considered, however, that to effect this reduction of sliming the mode of operating the mills becomes just as complicated as that of rolls, involving machinery for screening and elevating. (Elevating can be avoided by sending the oversize to other machines.) Under these conditions it is doubtful which class of machines can be operated at the lowest cost (the cost figures of this plant seem to point in favor of high-speed rolls), and the only serious objection to using them for this purpose would be the difficulty of keeping the faces true, which I understand has been found a serious drawback wherever fine grinding in rolls was attempted.

Regarding the point that the sliming of the mills can be reduced to the same amount as the sliming of the rolls, provided the mills make an oversize product of equal quantity, I want to add that this naturally only holds true for the conditions under which the test was made, that is, for reducing the maximum grains to about 1 mm. For coarser grinding the rolls, as hardly anybody doubts, are superior. In fact, some experi-

This is an additional reason why the formation of slime should be avoided as far as possible by either replacing Chilean mills by high-speed rolls or by operating the Chilean mills in the manner suggested above, namely, grinding in stages. It has been reported that the Utah Copper Company is departing from the old method of running Chilean mills by using rather coarse screens on the mills and regrinding the coarser sizes of sands, which, judging from above tests, seems a commendable step.

The question whether high-speed rolls or Chilean mills with stage grinding are more economical can only be decided by tests on a practical scale extended over a long time. The experience of the Miami mill, where Mr. Burch is installing high-speed rolls of his own design in one section, to be compared with the Chilean mills of the other sections, may render such a decision possible.

Morenci, Ariz.

### Duralumin

In a recent lecture of Mr. L. M. COHN before the Verein zur Beförderung des Gewerbefleißes in Berlin, reported in *Electrotechn. Zeit.*, April 27, some interesting data on aluminium alloys are given, made by the Dürener Metallwerke in Düren i. Rh., Germany, and sold under the trade name "duralumin." These are alloys of aluminium with about 0.5 per cent magnesium, 3.5 to 5.5 copper, and 0.5 to 0.8 manganese. These additions are claimed to increase very materially the breaking strength, ductility, hardness and chemical resistivity of the metal.

The specific gravity of the different brands of duralumin varies between 2.75 and 2.84. The melting point is 650° C. The electric conductivity is "less than that of pure aluminium." The hardness of soft sheets, 7 mm thick, is 98 to 125, hence three times greater than that of pure aluminium and twice that of soft brass for cartridges. By rolling the hardness can be increased to 170. "The modulus of elasticity for alloy 681 A is 700,000 kg per square centimeter, the shearing strength 30 kg per square millimeter, the breaking strength about 50 kg per square millimeter, the elongation for a sheet, 2 mm, which is about 4 per cent." Since above 150° C. the strength rapidly decreases, duralumin should not be used above this temperature.

Special advantages of duralumin are its light weight and resistivity against chemical influences. But it should not be used in contact with copper or brass, but rivets of iron, or preferably duralumin, should be employed. Various kinds of vessels and fixtures are now made from this new alloy. For the airship just finished for the British army duralumin has been used throughout as material of construction.

TABLE V.

Trommel.	Undersize.
0-20.....	0.32
20-30.....	5.24
30-50.....	13.28
50-100.....	22.91
100-200.....	8.23
200-∞.....	50.02
	100.00

ments along this line showed that the work of rolls operating in conjunction with a 2½-mm screen could, as far as minimum sliming is concerned, not be equaled by mills.

A fact which should be considered in judging the figures obtained in these tests is that in actual practice the results will be slightly different as the results of the concentration tests are based on the assumption that the concentration following the grinding is perfect. As a matter of fact the slime tailings from concentrators mostly show considerable amounts of free mineral on panning, while the coarser sizes are nearly free from such material.

## Recent Progress in Calorimetry.

### Details of Apparatus and Method.

BY WALTER P. WHITE.

Last April, in an article in these columns describing recent progress in calorimetry, it was shown that most errors in the past have been due to uncertainty in the conditions attending a determination; that these uncertainties can be avoided by preventing evaporation, adjusting and regulating the speed of stirring and removing the calorimeter from the influence of all bodies of unknown or uncertain temperature; that the various lag effects can easily be made negligible; and that the preponderant *unavoidable* error is then in the temperature measurement.

The advantage which may be sought from the new methods will differ in different cases. For instance, one worker will wish chiefly to diminish his accidental errors—that is, to make his own results agree better among themselves—another may find it more important to reduce the systematic errors which produce discrepancies between the results of different observers; still others, satisfied with the accuracy they are now getting, may yet welcome an increase in the speed or convenience of their methods. Of these three advantages, the avoidance of accidental irregularities has presented the greatest difficulties and is most important. It will be further discussed presently. The securing of concordant results among different observers is often at present a great desideratum in commercial work. Its lack is sometimes acutely felt even where the accidental errors are satisfactorily small. It is, however, an easier problem than the other. It will be treated first.

*Systematic variations between different observers* may be due to four causes. (1) Error in some auxiliary process or observation (for instance, with the bomb calorimeter, incomplete combustion, impure oxygen, inaccurate weighing, etc.). (2) Error in the value taken for the heat capacity ("water equivalent") of the calorimeter. (3) Error in the thermometer calibration. (4) Various errors due to lag which, as already pointed out, produce the effect of an error in the value of the heat capacity. The simplest and by far the surest way to eliminate all these errors, it is generally recognized, is to make a direct calibration of the calorimeter under actual working conditions, using some standard substance of known thermal properties. A familiar instance is the calibration of bomb calorimeters by determining with them the heats of combustion of sugar or benzoic acid, whose true values are pretty well known. Results obtained with these calorimeters thus become definite, and comparable with those of others, and their absolute accuracy will increase with every increase in our knowledge of the standard values.

With this method of procedure, of course, it is essential that there be no change either during the calibration or afterward in the errors whose effect it is sought to eliminate. Changes in auxiliary processes, though important, do not fall within the plan of the present paper; changes in the water equivalent, though also important, do not seem to call for discussion here, and the same may be said of errors in the thermometer calibration. But errors due to lag are not so well understood, and should perhaps be discussed briefly.

The lags most likely to produce actual error are those due to bodies of uncertain temperature, such as covers not touching the water of either calorimeter or jacket, shields and other large masses within the jacket, or the jacket itself if it consists merely of shields and contains no water. These lags will be constant, and will, therefore, not be productive of appreciable error in a calibrated calorimeter as long as the conditions affecting them do not change too greatly. But the one who, therefore, counts on ignoring them, of course, does so at his own risk, and must, to avoid error, not only be able to keep the essential conditions always constant, but must also be sure that he fully understands what *all* the essential conditions are.

It should not be supposed, however, that the errors, if any occur, would be large. These lags only alter the cooling correction by a fraction of itself; the cooling correction is only about 2 per cent of the total heat quantity, and no change of conditions is likely to alter the lags consistently by more than a rather small fraction of themselves. Hence, while these lags might cause considerable discrepancies between the results of calorimeters whose water equivalents were merely computed, they are not likely to cause in calorimeters directly calibrated any systematic errors greater than 1 part or 2 parts per mille. Present data do not seem sufficient for a more definite statement, since most of those who have given any particular attention to these lags have preferred to eliminate them rather than to bother with them.

The preceding suggests one general consideration. In many cases the presence of large lag effects is doubtless due to a legitimate attempt at simplicity of apparatus, but it also often results from an effort to increase accuracy by diminishing the magnitude of the cooling correction. This, of course, results from the mistaken notion that the cooling is the main source of error. But appreciable error rarely or never arises from the main part of the cooling correction; it comes from the smaller but variable subsidiary effects; hence a very large decrease in the total value of the cooling constant is a positive disadvantage *provided*, that it is accompanied by even a slight increase in the variations and conversely. The failure to appreciate this fact has frequently led to an unfortunate design or procedure. For instance, calorimeters have been considerably used in which the jacket consists of two fiber pails. If the space between these pails were to be filled with water, slightly stirred, the cooling correction would increase, but the errors would decrease because the environing temperature would become more constant. Similarly, where metallic shields are used inside a water jacket. Again, the substitution of Dewar flasks for metallic calorimeters has seemed to many persons an enormous improvement on account of the accompanying decrease in the cooling rate. (It is perhaps not everywhere known that use as a calorimeter was the original object of the Dewar flask, which antedates liquid air.) Of course, such a decrease is, other things being equal, a desirable thing, though less important than many appear to have supposed; the rate is, to judge from two recently reported cases, about one-fifth the usual one, but this is a very long way from giving anything like five-fold accuracy. On the other hand, in the Dewar flask, where there is a continuous glass connection between the calorimeter proper (inside) and the jacket (outside), the lag effects and the water equivalent are hard to determine and vary as the water level changes. Hence, while these flasks, if used with proper precautions, often have great advantages, they are not likely to prove particularly valuable in cases where it is supposed that their small cooling factor is alone enough to secure accuracy without special precautions.

Another case where the advantages of reducing the cooling correction have been overestimated is the case of adiabatic methods. In these methods the jacket is heated so as always to be at the same temperature as the calorimeter; there is thus (theoretically) no direct heat flow at all from the calorimeter (though a correction for the effects of stirring and evaporation is, in general, still necessary). This total absence of direct cooling is generally supposed to increase accuracy. Of course, it does nothing of the sort (in determinations of ordinary length). In fact, Professor Richards, who has been a leading exponent of the method, did not expect to gain accuracy from this source as much as from the elimination of certain lag effects. But it is now known that the errors from these effects are negligible or non-existent, though this was not known at the time when the method was introduced. There is now no good reason to suppose that adiabatic methods have any advantage in accuracy in determinations of ordinary length. They may often have decided advantages in convenience.

The value of a small cooling correction has also loomed large to those experimenters who have suggested that the calorim-



eter should be of such a shape as to have the minimum surface. As a matter of fact, differences of shape, unless extravagant, have but slight influence on the cooling rate, and hence have an altogether insignificant effect on the accuracy. The shape of the calorimeter should be chosen with reference to facility in stirring, and, of course, to convenience in construction or manipulation.

Passing now to consider the *accidental errors*, which set the present limits to calorimetric accuracy, the principal conditions for good work are: Constancy of conditions and sufficient thermometric sensitiveness. The means of securing these are in detail much as follows:

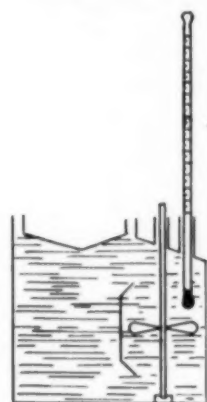


FIG. 1.—THIN SECTION OF CALORIMETER WITH FLOATING COVER IN CONTACT WITH WATER.

*The Calorimeter.*—To avoid lag errors projections should be avoided as far as possible, especially those of poor heat-conducting material. For the same reason, if there is any cover, it should be in direct contact with the water. Unless the calorimeter is to be always operated at a temperature lower than the jacket, the control of evaporation will require also a rather tight cover. A cover for the jacket alone will not answer at all. The simplest cover to manipulate is a floating cup, about 1 mm narrower than the calorimeter opening. The evaporation with such a cover will seldom reach 1 mg per minute, which means 0.6 calory heat loss a minute. If the cooling correction is (as usual) of the type which eliminates the effect of a constant evaporation, and if there are 2 or 3 liters of air space inside the jacket, the error due to evaporation then will seldom be as much as 0.2 mille for an ordinary determination, involving 6000 calories and lasting not over 10 minutes. Or, the edge of the cover can be made to rest in a narrow groove, and the joint sealed with 300 mg or so of oil, when evaporation is, of course,

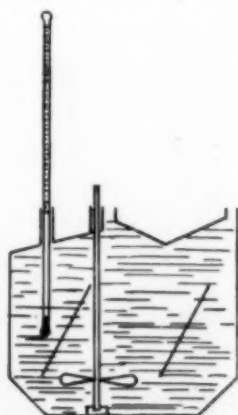


FIG. 2.—THIN SECTION OF CALORIMETER WITH FLOATING COVER. THE INCLINED TUBE GIVES CENTRAL STIRRING WITHOUT ENCUMBERING THE OPENING.

practically nil. Other fastenings are also possible, since absolute tightness is not needed. With such, since the water must touch the cover, the amount of water must be properly regulated. This is easily and quickly done by sucking the water out, down to a certain level. A tube shaped like the letter "J" is probably best for this purpose, and gives levels constant to one-tenth or two-tenths of a millimeter. Such a tube, stuck through a large cork which rests on the calorimeter rim, when in use, makes as good an adjuster as any.

The stirrer shaft and thermometer can run through the movable cover, but are more conveniently inserted through a fixed cover, or half deck, as shown in Fig. 1. The stirrer, unless there is strong reason to the contrary, should be a propeller, because that is more efficient and causes less evaporation than an up-and-down stirrer. The effectiveness of propellers is usually promoted by inclosing them in side tubes, as in the figure. Such tubes should not be too small. Suppose, for instance, two calorimeters, in one of which the side tube is two-thirds as wide as the main calorimeter, while in the other it is one-third as wide. For any given effectiveness, then, the speed of the water in the narrow side tube is four times as great as in the other, and, since the heat is about proportional to the

cube of the speed of flow, the heating is possibly 64 times as great. But friction is greater for the same speed in a narrow tube, so that the heating may be 100 times as great or more and is certainly far greater than in the wider tube. The disadvantage of throttling the stream of water is thus evident. Throttling is at a minimum if the stirrer is in a central tube. An arrangement by which this construction can be secured without having the stirrer shaft interfere with the calorimeter opening is shown in Fig. 2. This arrangement has proved very successful in reducing the heat of stirring.

The jacket, for the best results, should contain water, whose temperature should be kept uniform by stirring, and should be measured. The water should surround the calorimeter completely, so that the whole surrounding temperature is definite. The water, therefore, should be *above* the calorimeter, as well as below and at the sides. Several satisfactory methods of accomplishing this have been used. One of the best is as follows: The calorimeter chamber is a vessel open at the top and sunk in a larger vessel; the space between the two, partly open at the top, contains the water; the cover is a flat box, airtight except for two large tubular openings which project downward and reach below the surface of the water in the lower vessel. The cover is filled with water, which is made to stay there by atmospheric pressure; the stirrer is directly under one of the tubular openings, and so produces circulation in the cover as well as in the lower vessel. (Fig. 3.) The opening of the chamber may be provided for in either of two ways: (1) The cover, tubes and all, is moved directly aside; this method agrees best with a design having a square outer ves-

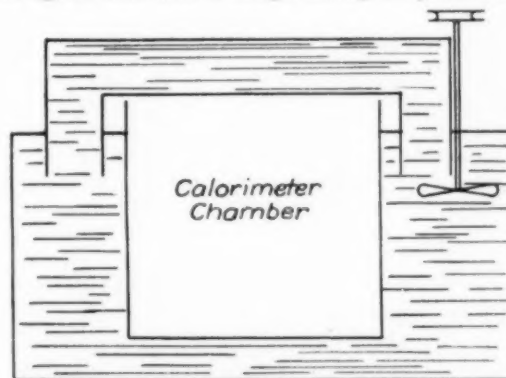


FIG. 3.—THIN SECTION OF CALORIMETER JACKET WHICH SURROUNDS THE CALORIMETER COMPLETELY WITH A SINGLE STIRRED BODY OF WATER AND IS READILY OPENED AT ANY TIME.

sel and two half covers, one of which transmits the thermometer, stirrer, etc.; this half can be kept stationary while the other is moved to expose the calorimeter opening. Both are moved apart to remove or insert the calorimeter. (2) In the other method the two tubular openings are near each other and the single cover swings around one of them as an axis in exposing the chamber and calorimeter; the thermometer passes through either a hole in the cover or a notch in its edge; partitions guide the circulation.

The upper bearing for the stirrer should be on the jacket, or, at any rate, not on the calorimeter itself. If the calorimeter is always below the temperature of the jacket the jacket may almost as well be left open at the top, since there is comparatively little tendency for heat to pass downward across an air space at ordinary temperatures. Of course, such a jacket is not to be unreservedly condemned, even where the calorimeter is sometimes warmer than it, if the highest accuracy is not required. A good deal will depend on how constant the room temperature is. There should be no difficulty in determining by actual observation how great is the direct influence of room temperature upon the calorimeter. A few hours' observation of the cooling rates, with different relations between jacket and room temperature, is all that is required. The error likely to result

through the use of an open jacket can then be readily estimated for any given variation in room temperature.

The necessity of measuring the jacket temperature can also be avoided if certain cooling correction methods (e.g., the Pfaundler) are used, and if that temperature is also kept practically constant. It can easily be shown that variations in the jacket temperature arising from the temperature change in the calorimeter will be less than 0.1 per mille if the jacket has ten times the heat capacity of the calorimeter. Changes in the jacket arising from the room temperature are more serious. If the difference between room and jacket is equal to the calorimetric interval the resulting error will often reach, and may exceed, 1 per mille. Here, also, the probable magnitude of the error for a given difference of room and jacket can readily be found experimentally—in this case by a little observation of the cooling rate of the jacket.

**Summary.**—Systematic errors in calorimetry can usually be eliminated by a direct calibration, except for certain lag errors, which can be avoided by proper construction and procedure. Accidental errors can be greatly reduced by various features, described above, in the design of calorimeter and jacket. Temperature measurement and the calculation of temperature corrections will be treated in a third paper.

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### Positive Rays and Chemical Analysis

The discourse on "A New Method of Chemical Analysis" which Sir J. J. THOMSON delivered at the Royal Institution in London on April 7 showed that a line of research, of which Professor Thomson gave a preliminary account before the Sheffield meeting of the British Association, has led to most remarkable results. The following account of the lecture is taken from *London Engineering* of April 14:

There is nothing chemical in the new method of analysis. But the study of the positive rays (Kanalstrahlen) tells the experimenter not only what gases he is actually dealing with in the apparent residual gas of his vacuum tubes, but in what state—atomic, molecular, or molecular aggregations—they are, all deduced from measurements of deflection of the rays, which measurements give a clue as to the atomic weight (or equivalent). This is the strength, and possibly also the weakness, of the new method, which bears some resemblance to spectroscopy.

The new method identifies the elements by their masses. It informs the experimenter that some substance having a certain  $e/m$  (ratio of electric charge to mass) is present, and as the experimenter knows with some degree of certainty what substances he starts with, the method affords a valuable help to the chemist, especially as it is wonderfully sensitive and records the presence and mass of elements or radicles which are far too evanescent to be isolated.

Sir Joseph said, in introducing his subject, that he approached a chemical problem with some trepidation, since chemists were fighting men. But his weapons were bullets traveling at 1000 miles per second. The positive rays were positively electrified particles attracted to the negative electrode. When that electrode was perforated (by Goldstein's Kanal) the particles would pass through the cathode in streams which, in neon, had a beautiful orange-red color, as was shown. The particles were deflected both by the magnetic and the electric field, and the research depended upon the measurement of these deflections.

There are several arrangements of the bulbs possible, and these bulbs are sometimes very large. In one of the new arrangements (Fig. 1) the tubular cathode is continued backward in a fine tube, terminating at two electrodes, between which an electric field is established. A magnetic field is also provided so that after passing through the two fields the particles strike the flat screen of willemite, closing the tube.

With the magnetic field alone in action, the original light spot O (Fig. 2) of the undeflected particles is shifted to N; the deflection ON being equal to  $Ae/mv$ , where A was a constant depending on the intensity of the field and the size of the tube, while  $m$  was the mass of the particle,  $e$  its charge, and  $v$  its velocity. The electric field similarly deflected the particle to OM, at right angles to ON, and  $OM = Be/mv^2$ , where B was another constant.

When both fields were excited the particles would be shifted to P, and it could easily be shown that the ratio of  $m$  to  $e$  should vary as the ratio of OM to ON<sup>2</sup>. If, now, all the particles were of the same kind and had the same speed, the position of P would merely depend on  $m/e$ , and a number of spots P—as many as there were different kinds of particles—would be seen. But the particles of the same kind did not move all at the same speeds, and each spot was drawn out into a curve, which was a

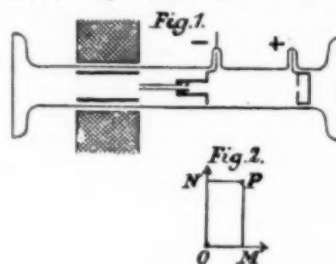


FIG. 1 AND 2.—ARRANGEMENT OF DISCHARGE TUBE.

parabola if  $m$  were constant.

The lecturer and his assistants had at first made the measurements directly on the screen while the experiment lasted. But that was very laborious, and they had substituted a photographic plate for the screen so that each particle photographed itself. They had placed the photographic plate first outside and then inside the bulb (as has also been done in similar researches conducted by Koenigsberger and others), and with the aid of a slide shutter, due to Sir Joseph's assistant, Mr. F. W. Aston, the exposure was made at the proper moment and several photographs were taken on the same plate.

In each case the first photograph was taken with the magnetic field producing a deflection upward, the second with the reversed field giving a deflection downward. Thus they obtained full parabolas (not only one branch), and they could ascertain the zero from which to measure with more definiteness. In the slide used the photographic plate was suspended by a silk thread wound round a plug worked in a glass-ground joint.

Fig. 3 illustrates the beautiful curves obtained with a tube containing nitrogen isolated from the atmosphere. The central light spot indicates the original position of the undeflected ray. There were many faint and bright curves, sometimes beady; their number suggested the presence of many substances, constituents or impurities; the argon curve was present, for instance, while absent on another photograph taken with nitrogen prepared from ammonium nitrate. Most of the curves were on the right side of the photograph, in which direction the positive particles were deflected. But there were also some faint curves on the left-hand side, showing that some negatively-charged particles had found their way through the cathode.



FIG. 3.—PHOTOGRAPHIC PICTURE OBTAINED.

The uppermost curve always corresponded to the hydrogen atom, and this was present on all plates from discharges through all substances. Traces of oxygen, carbon and mercury were also found on almost all the plates, no matter what substance they were experimenting with. The other substances followed in the order of their atomic or equivalent weights.

Thus, taking the ratio of  $m$  to  $e$  as unity in the case of



hydrogen, it is possible to calculate from measurement of the curves the relative value of this ratio for the other particles impressing themselves on the plate. We reproduce below figures deduced from the measurements of the parabolas of Fig. 3, showing the discharge through atmospheric nitrogen; the enumeration starts from the top of the diagram.

Positive Side.	Negative Side.
1.00 H +	1.0 H —
1.99 H <sub>2</sub> ++	11.2 C —
6.80 N ++	15.2 O —
11.40 C ++	
13.95 N +	
28.1 N <sub>2</sub> +	
39.0 A +	
101.0 Hg ++	
198.0 Hg +	

The + and — indicated, the lecturer explained, the simple or double charge carried by the particle. The H=1 corresponded to the hydrogen atom carrying a single charge; the second, H<sub>2</sub>=1.99 (instead of 2) to the hydrogen molecule; 11.40 C+ to a carbon atom (C=12); the 6.80 N++ to a nitrogen atom carrying two charges (N=14); the 13.95 N+ to the nitrogen atom; the 28.1 N<sub>2</sub>+ to the nitrogen molecule; the 39.0 A+ to the argon atom (A=40); and the two last curves, 101 Hg++ and 198 Hg+ to mercury (Hg=200), carrying one and two charges respectively. The agreement between the deduced values and those assumed by chemists (figures added in brackets) was very close. The hydrogen, carbon, and oxygen found on the negative side are all in the atomic state.

Comparing the new method with spectroscopy, Sir Joseph pointed out that the spectroscopist, observing a new line, was not always certain whether he was not looking at a line of an old known substance produced under special thermal or electrical conditions. In his new method the particles wrote their names on the plate. The method was also exceedingly sensitive. He had traced the presence of helium in this way, when it could not otherwise be detected, requiring only a few particles of the substance confined in a vessel at a pressure of 0.03 mm. of mercury. The accuracy of the measurement was not dependent upon the weight of the substance present.

Although these researches had only been going on for a few months, he realized an accuracy of 1 per cent with 0.01 milligram of substance. No chemist would undertake a determination of atomic or molecular weights under similar circumstances. Another great advantage was that the purity of this substance—the great difficulty of the chemist—was of no consequence. The method sifted the particles, merely giving an additional curve for each constituent. It is further noteworthy that the atom or particle recorded itself within a millionth of a second of its production; thus substances were detected of which the free existence had not, so far, been proved by other means.

The lecturer then exhibited slides of the curves obtained with other gases—chemically-prepared nitrogen, carbon monoxide, carbon dioxide, methane, chloroform, carbon oxychloride, etc., and he reproduced also the tables of the measurements. A few characteristic features may be pointed out. The chemically-prepared nitrogen did not give the argon line, as it should not. A faint mercury curve 65.5 Hg+++ was frequently observed, but somewhat uncertain. The carbon compounds showed 6.0 C++ in addition to the 12.02 C+.

In the experiments with methane, CH<sub>4</sub> (marsh gas), a veil in the neighborhood of the carbon line had finally been resolved into four curves, 11.95 C+, 12.9 CH+, 14.05 CH<sub>2</sub>+, 14.9 CH<sub>3</sub>++; these were familiar groups to the chemist, but had never been obtained in the free state.

They hoped to study the transformation products of radio-activity substances in the novel way. In the case of chloroform, CHCl<sub>3</sub>, and some other compounds, two obscure faint lines were observed, 1.5 and 3, the 1.5 also on the negative side;

the 3 might possibly be C++++. The lecturer did not comment on the fact that none of his photographs exhibited any helium curves.

Passing to general conclusions, Sir J. J. Thomson remarked that, leaving accidental impurities out of consideration, this analysis always demonstrated the presence of the respective substance in several states or systems, atomic, molecular, or complex aggregations, carrying one or several positive and sometimes also negative charges.

Oxygen, for instance, was found in nine modifications, comprising ozone, O<sub>3</sub>× (the suggestion is not new to chemists), O—, and uncharged atoms and molecules. In view of this variety, it did not appear surprising that substances gave many kinds of spectra under different conditions; the various systems might give rise to different spectra.

On the negative side were found the atoms of hydrogen, carbon, oxygen, and chlorine, but never in the molecular condition; the last two would naturally be expected on the negative side, and the association of hydrogen (though a highly electropositive element) with negative charge was no longer a novelty.

As regards these curves on the negative side, it would appear that negative particles were carried through the cathode and that they were picked up by neutral particles and held by attraction. Only the atoms, not the molecules, seemed to be able to do this, and the phenomena illustrated the different behavior of atoms and molecules. Apparently the atom, not the molecule, was capable of exerting momentarily a very powerful attraction. The explanation was probably that the atom had more freedom of motion than the molecule. When magnetism acted on a sphere of a magnetic substance, the electricity within that sphere was free to move and to readjust itself in accordance with the magnetic induction, and a strong attraction resulted. On a sphere of sulphur the freedom was limited and the attraction was weak.

In illustration of this view, about half a dozen compass needles had been mounted, each on its vertical pivot, on a piece of cardboard, which was held suspended by strings in front of an electromagnet. When the electromagnet was excited, the whole system on the cardboard was attracted toward the electromagnet; but when the needles were taken off their pivots and placed on the board, on which they could no longer move freely, hardly any attraction was observed. Similarly, Sir Joseph remarked, there were stiff and freely-moving atomic and molecular systems. It depended upon the numbers of corpuscles in the atom; one corpuscle more than a critical number would (as he had explained on other occasions) impart to the atomic system one freedom of motion, one bond or one valency; two free corpuscles would correspond to two bonds and two valencies. When the atoms joined one another to form molecules, the bonds were linked, the system became rigid, and it failed to attract bodies outside. These researches, Professor Thomson concluded, might help forward the solution of the problems of chemical combination.

**Chemical Analysis in British National Physical Laboratory.**—Last year's report of the (British) National Physical Laboratory contains an account of some researches on chemical analysis (London *Eng'ing*, April 21). The small boats of fire-clay wanted for combustion tests were formerly molded and then pressed. The clay is now forced through a die and delivered as a U-shaped strip, which is pinched off at suitable lengths—a more rapid and neater process. The new electric oven for carrying on spontaneous-combustion experiments is a cubical box with asbestos walls, containing a copper box, 18-in. cube, in which the material is placed; a temperature of 500° C. can be kept constant within 1°. There is a free air space of 3 in. around the box. When materials like cotton wool or charcoal are examined a rise of the thermo-couples inside the material above those outside would indicate chemical changes which might lead to combustion.

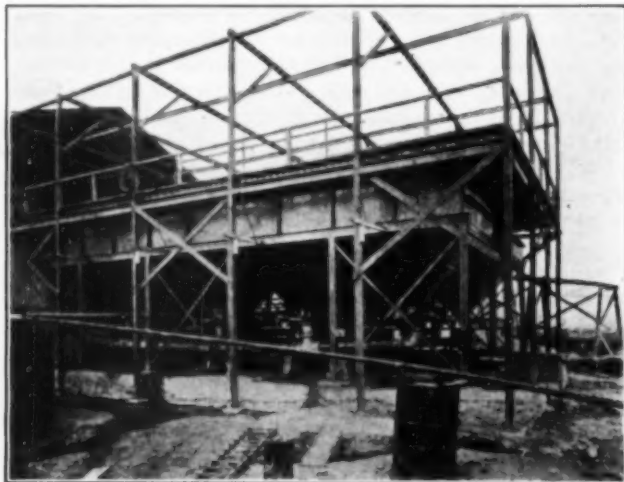


### The Butters Filter Plant at the Crown Mines, Ltd.

The February issue of the *Journal* of the Chemical, Metallurgical & Mining Society of South Africa contains an interesting account of the visit of the members of the society to the Crown Mines, Ltd.

The present metallurgical equipment is 675 stamps with 20 tube mills, and sand and slime plants, made up as follows:

A. Crown Deep .....	300 stamps and 10 tube mills.
B. Langlaate Deep....	200 " " 6 " "
C. Crown Reef .....	120 " " 3 " "
D. Bonanza .....	55 " " 1 " "



VIEW OF BUTTERS FILTER PLANT, FROM BENEATH.

With the present plant they have a capacity of 165,000 tons per month.

A fifth mill is being erected of more modern type, which, when completed, will increase the total crushing capacity to well over 200,000 tons per month. Special features are the tandem classifications and the tube milling at A plant; further, the installation of a 300-leaf Butters vacuum filter slime plant at C plant, which is unique not only on account of its being the first vacuum filter plant erected on the South African gold fields, but also because it occupies the site of the first slime plant designed and erected on the Rand by Mr. J. R. Williams.

The following is a description, by Mr. C. G. PATTERSON, of the Butters vacuum filter plant as installed and worked on the Crown Reef section of the Crown Mines:

The plant consists of two stock vats equipped (temporarily) with air agitation to keep the slime in suspension. After the values have been dissolved in Brown agitators the pulp at a dilution of 2 to 1 is transferred to the stock-pulp vats, from where it is fed to the filters as required.

There is one wash solution vat. All precipitated solution is delivered to this vat to be used subsequently for a wash in the filters. There are two Butters filter boxes, each fitted with 150 Butters vacuum filter leaves and one 14 x 14 Goulds vacuum pump. Each filter box is an independent filtering unit. One 10-in. Robeson-Davidson slime pump handles pulp and solution to and from the filter boxes and the stock vats, serving the boxes alternately.

The piping is arranged round the pump in a loop, having four valves interposed so as to reverse the direction of flow through the pipes. The pump is set in either the emptying or filling position instantly, by means of one pilot valve introducing hydraulic pressure into the cylinders of the four valves simultaneously.

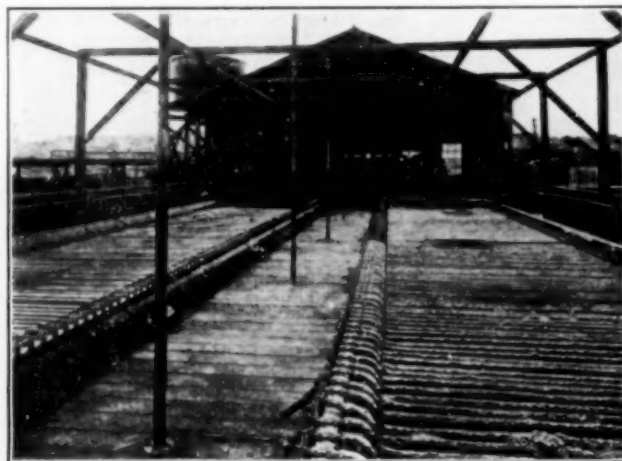
The motor for the 10-in. pump, and also valves in the pump systems, are operated from the switchboard. The style of plant

is called the "pumping system" and the process of filtration is performed as follows:

**Forming the Cake.**—The filter box is filled with pulp to a point over the top of the filter leaves and a valve opened connecting the vacuum pump directly with the filters. Clear cyanide solution is drawn from within the filter leaves and delivered to the clarifying vat for precipitation, the slime remaining as a cake on the outside of the filters. The filters are kept submerged by refilling the box at intervals, and jets of air are introduced at the points of each hopper to keep the slime in suspension. When a cake 1 in. to 1½ in. thick has been formed, the surplus pulp is pumped back to the stock pulp vat and the box is then filled with solution to wash the cake. During the time of forming and washing the cake the vacuum is maintained at the highest possible point, but when the cake is exposed to air during the transfer of pulp and wash solution, the vacuum is reduced to 5 in. to prevent the cake cracking.

**Washing.**—The cake being formed by atmospheric pressure, the resistance and permeability are equal over the whole surface of the leaf, thus producing an ideal condition for the recovery of the valuable moisture contained therein, which equals 30 per cent to 35 per cent. Sufficient wash solution (about 2 tons per ton of slime) is drawn through the cake by the vacuum pump to effect a complete displacement of the original moisture. A portion of this solution goes to the clarifying vats for precipitation; the flow is then diverted to a stock vat to be used in making up new charges in the Brown treatment vats.

**Discharging.**—When the wash is complete the vacuum is disconnected and a reverse flow of solution (by gravity from the vat on the roof) is introduced to the interior of the filters, causing the cakes to drop. The surplus solution is then pumped from the filter box through decanters and returned to the wash solution vat. The mass of thick sludge remaining in the box is diluted with water and agitated with air for a few minutes to make a homogeneous pulp of 1 to 1, which is then pumped to the residue dam by a second 10-in. R. & D. pump, the delivery pipe of which is fitted with an automatic sampler.



VIEW OF BUTTERS FILTER PLANT, ON OPERATING PLATFORM.

#### Cycle of Operations.—

Filling box with pulp and forming cake, 45 minutes.

Transferring and washing, 70 minutes.

Discharging, 20 minutes.

Total time of cycle, 2 hours 15 minutes.

Tons treated per cycle, 1¼-in. cake = 50 tons each box.

**Acid Treatment.**—Five leaves are removed from each filter box every day, thoroughly washed with a spray of water and air, and then immersed in a vat of 2 per cent hydrochloric acid solution for the purpose of dissolving the calcium carbonate and keeping the leaves soft, pliable and in good working condi-



## The Methods of the United States Steel Corporation for the Technical Sampling and Analysis of Gases.

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This paper is descriptive of the methods selected by the chemists of the U. S. Steel Corporation, acting through the Chemists' Committee, for the technical sampling and analysis of gases. With the increased significance attached to the economic control of those industrial processes involving the combustion of fuels, and with the application of keen scientific research to the various problems involved, it becomes readily apparent that accurate knowledge of the composition of the gases encountered is a matter of prime importance. This fact is exemplified by the rapid increase in the use of internal combustion engines, using blast furnace or producer gas as a fuel, and by the increasing necessity of greater watchfulness upon the efficiency of boilers, stoves and furnaces. The need is obvious for the use by the laboratories of the United States Steel Corporation of a standard system of sampling and analysis of gases, in order that comparable results may be obtained with the maximum degree of accuracy, consistent with the minimum of time requisite for execution.

This description was consummated through a review of the practices specially written for this purpose, of all the laboratories of the Corporation engaged in the sampling and analysis of gases. The apparatus shown for the analysis is to be considered only as a type of the permissible form. The essential points are the exclusive use of capillary tubes, the permanency of connection of the auxiliary gases, compactness, and the applicability of the apparatus to the accompanying description. This form of apparatus and the methods as here described, are to take precedence over all others employed for the analysis of gases throughout the laboratories of the Corporation.

It is the desire of the Chemists' Committee here to acknowledge their grateful appreciation of the services of Mr. D. A. Barkley and Mr. R. J. Wysor, assistants in the Duquesne laboratory, in the preparation of this paper.

In the preparation of the accompanying standard methods for the sampling and analysis of gases, there has been an unwavering purpose to eliminate, so far as possible, tedious analytical procedures, or the use of cumbersome and antiquated forms of apparatus. It has been desired to adopt methods, inherently correct in principle, in conjunction with simplified apparatus, which will insure the requisite expediency, at times so necessary in commercial work, without an appreciable sacrifice in accuracy of results. While no notable originality is claimed in general for the substance of this paper, it is believed that the application of well-known methods, coupled with certain novel features in execution, and in the forms of apparatus used, will be presented. A sense of vagueness or lack of definiteness with reference to practical descriptions, it is believed, pervades the bulk of literature concerned with this subject. No apology is offered for the unabridged nature of the descriptions and explanations appearing in this pamphlet. The delineation of the methods has been made in considerable detail so as to be clearly intelligible to amateurs as well as to those better versed in the subject. The goal simultaneously attained by accuracy and speed of execution, and so much desired in chemical methods, has been striven for, with what success the future will demonstrate.

### Sampling.

The impossibility is recognized within the compass of this pamphlet of detailing a method for sampling gases, that would be applicable to all the works of the Corporation and the various metallurgical operations therein. It is preferred, rather, to make this description general in its scope, leaving to each individual operator the solution of the details to meet his own particular conditions. In the sampling of gas two kinds of samples are recognized, the regular and the irregular. The

former comprises all samples taken over a continuous division of this time. The results so obtained will constitute the regular or official analysis and they only will enter into comparison with like results from other works. Under the head of the irregular samples will be included all those samples taken for a shorter period of time than the minimum above given, and will represent momentary conditions of the particular operation in question, and are for the works' guidance only. All analytical reports shall show the duration of the time of sampling in order that the status of the results may be seen at a glance.

In sampling blast furnace or producer gas, which are considered homogenous as regards cross section of the main, the gas is withdrawn through a petcock on a pipe screwed into the shell of the main and extending in beyond the brickwork lining. In the absence of lining the gas may be withdrawn through a petcock on the shell, or when the main is inaccessible, on a pipe leading from the main and through which a constant current of gas passes.

In sampling flue gas it is necessary that the gas be withdrawn through a perforated pipe, which enters with air-tight connection and extends entirely across the flue. The pipe is closed at the anterior end and provided at the outer end by an aspirating device, operated by air, water, or steam (see sketch). The perforations in this pipe should be an equal distance apart, and, to obtain an equal flow through each opening, their combined area should be less than the cross sectional area of the pipe, three-fourths being considered a safe figure. The gas sample is withdrawn from the sampling pipe through a petcock situated between the flue and the aspirating device. This pipe may also be used in sampling blast furnace or producer gas; however, in place of the aspirator, the gas is allowed to escape under its own pressure.

An apparatus for withdrawing an accumulative sample is shown in the accompanying photograph. This appliance is one of many that may be used and has the advantage of simplicity of construction and operation. In obtaining a sample, the petcock, permanently attached to the main, flue or intermediary pipe before mentioned, is connected by a rubber tube with one hole of the doubly perforated stopper in the two gallon aspirator bottle. This bottle is full of water which has been saturated with the gas to be sampled and which may also contain one per cent of sulphuric acid. The lower opening of this bottle is connected by a rubber tube with a similar opening of another bottle placed on a lower level, the rate of flow of water from the upper to the lower being controlled by a screw compressor. The petcock being open, the screw compressor is released and the gas rapidly displaces the water in the upper bottle. On closing the petcock, reversing the bottles, and opening the pinchcock on the rubber tube leading from the second hole in the rubber stopper, the gas is rapidly expelled into the air until the rubber tube constituting the exit is full of water. The pinchcock is closed, the bottles reversed, and the upper one filled with gas, the rate of inflow of gas being so controlled by the compressor that the bottle is filled in the designated time, one-half to twenty-four hours.

A portion for analysis is transferred from the bottle to the small sample tube (No. 2, Analytical Apparatus). This tube, made of suitable material, is two inches in diameter, eight inches long, has conically shaped ends terminated by petcocks and a capacity of about 300 cc. This sample tube being filled with water, including the upper petcock, to exclude all air, is attached to the rubber tubing constituting the exit from the gas bottle, which is also full of water. The position of the aspirator bottles is reversed, placing the gas under pressure, the pinchcock is opened, the upper then the lower cocks on the sample tube are opened and the gas is allowed to displace the water in the tube and flush through for a short time to saturate the moisture adhering to the sides. The lower, then the upper cock on the tube is then closed, leaving the gas under slight pressure. The sample is delivered to the laboratory and analyzed as soon as possible to minimize the loss of carbon dioxide.



When so desired, a gasometer may be used for withdrawing a larger sample of such size that calorimetric determinations may also be made on it. If rough gas is to be sampled continuously, it is first passed through a suitable apparatus for removing the dust. The water in the gasometer is used continuously and as long as practicable. A small sample for analysis is forced through a petcock on the holder and suitable rubber tubing connection into the sample tube in the manner previously described.

#### Analysis.

**The Apparatus.**—1. The apparatus shown in the accompanying Fig. 3 has been designed with particular reference to its adaptation to the methods subsequently described. The distinguishing features in its design are the capillary tube of 1 mm bore, the accessibility of the auxiliary gases, oxygen and hydrogen, and the central location of the burette in the apparatus, thus decreasing the error due to the capillary space. Drawings of this apparatus, which have been copyrighted, have been supplied to Messrs. Eimer & Amend of New York, the authorized makers, who are prepared to supply it in whole or in part.

The general disposition of the apparatus is obvious. On the

maining 25 cc are graduated in fifths, and may be read in tenths. The numerations are from the bottom upward. The burette is surrounded by a water jacket, thereby maintaining practically a constant internal temperature throughout an analysis.

The pipettes have two compartments, and to the open side a thin rubber bulb is attached. This protects the reagent from the atmosphere. The pipettes will conveniently hold 100 cc of gas and 260 cc of the reagent, with the exception of the one for phosphorus. This pipette was designed for the use of stick phosphorus, and when moderately filled with this reagent will hold 100 cc of gas, and sufficient water to form a seal. Thus the gas is exposed to the maximum surface area of the phosphorus, facilitating the removal of oxygen. In filling, the phosphorus is introduced through an opening at the lower end of the pipette. The stem rises into the base of the pipette for a distance of about  $\frac{1}{4}$  in., thus preventing the sticks from obstructing the orifice.

2. A  $\frac{1}{2}$  pint Kipp apparatus for generating hydrogen from C. P. stick zinc and dilute hydrochloric acid.

3. An aspirator bottle containing oxygen and nitrogen in predetermined proportion.

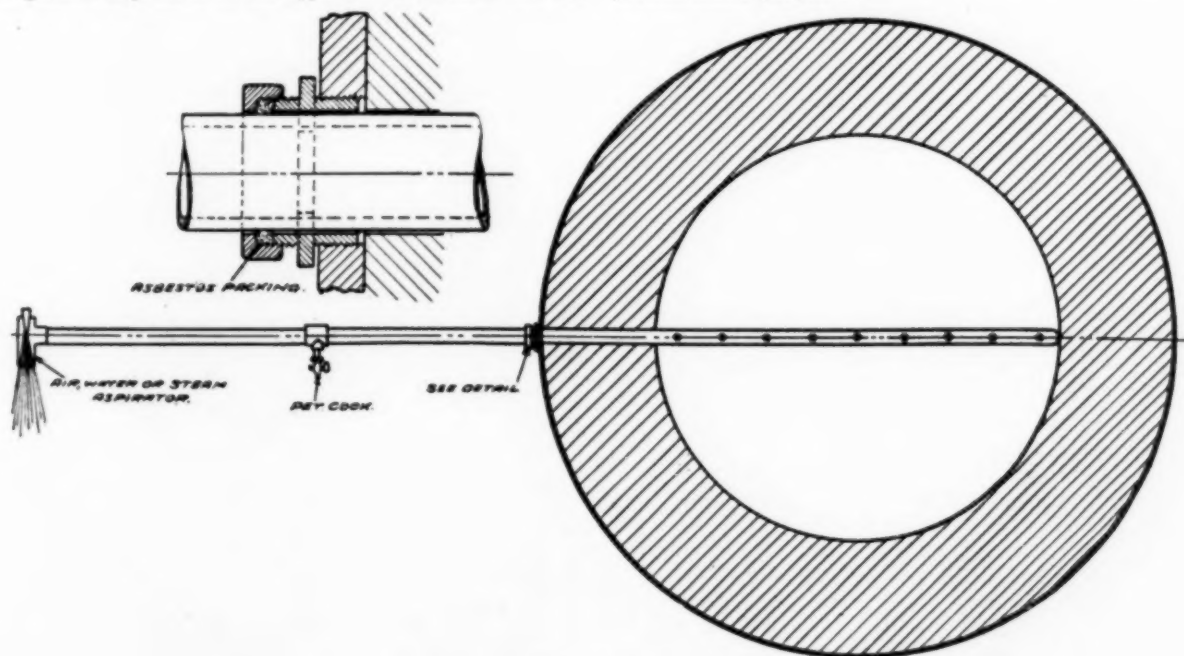


FIG. 1.—SAMPLING TUBE FOR FLUE GASES.

extreme left end of the capillary the rubber tubing connection leading to the Kipp apparatus (No. 9) is placed, while the connection to the oxygen supply (No. 7) is made on the end of the first stopcock. To the first capillary stem is attached the explosion pipette (No. 8), the platinum leads within which are partly covered with glass to prevent the spark from short-circuiting; next in order the pipette containing potassium hydrate solution (No. 4) is placed, followed by the burette (No. 3). To the right of the burette are situated the pipettes containing stick phosphorus and fuming sulphuric acid (No. 6 and No. 5, respectively).

The stem of each pipette is ground so as just to clear the corresponding stem of the capillary with which it is connected. The stem of the burette must not be altered, but is to be precisely adjusted to the stem of the capillary tube by regulating the height of the support at the bottom. The calculated volume of the capillary tube is approximately 0.2 cc, but since one-half is kept filled with water, the capacity of the burette and capillary is 100.1 cc. Since the majority of readings are made in the lower part of the burette, the first 75 cc are graduated in tenths, and by interpolation twentieths may be read. The re-

An induction coil of sufficient size to give a  $\frac{1}{8}$ -in. spark. The current required for this coil is derived either from dry cells, a storage battery, or from direct-current lighting circuit with a suitable rheostat connection.

**Reagents.**—1. Potassium Hydrate. The pipette used for this reagent is filled with 260 cc of a solution of approximately 1.27 specific gravity. The absorbing power is in excess of 40 cc of carbon dioxide per cc of solution.

2. Stick Phosphorus. This reagent is prepared in sticks of about 4 mm or 5 mm diameter, and of suitable length for the absorption pipette, by melting the phosphorus under water in a test tube immersed in a vessel of water at a temperature of about 50° C. A glass tube of the proper internal diameter is inserted in the molten phosphorus, and a column of phosphorus is drawn into the tube by means of suction to the desired height, when the tube is withdrawn and immediately dipped into a beaker of cold water. The solidified phosphorus is then pushed out with a glass rod into the reagent pipette filled with water. When in use the water in the pipette is renewed occasionally to remove the oxides of phosphorus in solution. The need for this is apparent when the fumes in the pipette are

slowly or incompletely absorbed in one or two minutes. The chamber of the pipette containing the phosphorus is inclosed with a piece of black paper to protect it from the action of light.

3. Fuming Sulphuric Acid. Two hundred and sixty cubic centimeters are required. The acid should contain at least 20 per cent of sulphur trioxide in excess. It will become discolored owing to its action upon the rubber tubing, but this does not appear to interfere with its efficiency. This action tends to harden the tubing, after which it apparently ceases.

4. Dilute Hydrochloric Acid. A mixture of hydrochloric acid—100 cc, and distilled water—400 cc, is poured into the Kipp apparatus, the middle chamber of which is well filled with C. P. stick zinc.

5. Saturated Water. This is used to fill the burette, the explosion pipette, and the leveling bottles. Care should be taken not to contaminate this water with any of the reagent solutions, as the longer it is used, the less will be the liability of error due to the absorption of gas. It is obtained by causing the gas to bubble through distilled water contained in a bottle for a reasonable period of time. The water is filtered, 1 per cent of sulphuric acid is added, and the mixture well shaken.

**Auxiliary Gases.—1. Hydrogen.** This is generated in the middle chamber of the Kipp apparatus by the action of dilute hydrochloric acid upon C. P. stick zinc. The apparatus should be flushed several times with freshly generated hydrogen to remove all traces of air, and the rubber tubing connected to the left end of the main capillary tube.

2. Oxygen and Nitrogen Mixture. This mixture should contain from 35 per cent to 45 per cent oxygen and from 55 per cent to 65 per cent nitrogen. The container, a  $\frac{1}{2}$ -gal. aspirator bottle, is assumed to have a volume in round numbers of 2000 cc. By calculation it has been found that a mixture of one-third oxygen, obtained from the oxygen tank, and containing between 95 per cent and 100 per cent oxygen, and two-thirds air will approximate 46 per cent oxygen and 54 per cent nitrogen in composition.

Suitable connections are made between two aspirator bottles, one being filled with water, the other containing enough to form a seal, and the rubber tubing connecting the two bottles is closed with a pinchcock. The volume of water in the former above the lower outlet is determined, and two-thirds of this amount is returned to the bottle, a mark being made on the side even with the water level; the bottle is then filled with water. A connection is made with the oxygen supply, the pinchcock between the two bottles released, and the oxygen is allowed to pass slowly into the bottle until the water reaches the indicated mark, the overflow passing into the second aspirator bottle. At this point the rubber tubing leading to the oxygen supply is disconnected, the second aspirator bottle is immediately lowered, and the air drawn in the upper bottle until the water level is even with the outlet. The end of the rubber tubing on the upper bottle is closed with a pinchcock, and the gases thoroughly mixed by agitation. The bottles are placed on their shelves, and the tubing connected to the stem of the three-way cock on the left of the gas analyzing apparatus.

**Methods of Analysis.—1. Percentage of oxygen in oxygen and nitrogen mixture.**

In the application of the following methods it has been found that a mixture of oxygen and nitrogen, in the proportion given before, is the most practical for use in the combustion of the component gases, but it is necessary to know the exact percentage of oxygen in this mixture in order that the amount of oxygen added for the explosions may be known. The object in introducing this mixture instead of oxygen alone is that a larger volume of the former can be added, and only a normal excess of oxygen will be present after the first explosion, thereby keeping the explosion ratio as high as practicable and reducing the flame temperature, thus minimizing errors due to the combustion of nitrogen. The explosion ratio is the proportion of the inert to the total gases entering into the combina-

tion. The oxidation of nitrogen cannot be entirely avoided since oxides of nitrogen are formed in all explosions in amounts varying chiefly with the temperature attained. The design of the explosion pipette, owing to its eudometric shape, is an aid in avoiding the combustion of nitrogen in that the flame movement is slower, and necessarily the production of heat is lower, than in the spherical form of pipette. Experiments have been made on the gases discussed in this paper, and approximately quantitative determinations made of the oxides of nitrogen formed in the combustions. It has been found that with this mixture, and the explosive ratios as high as practicable, the errors due to oxides of nitrogen are negligible. With pure oxygen, even though the explosive ratio is the same, the formation of oxides of nitrogen is markedly increased.

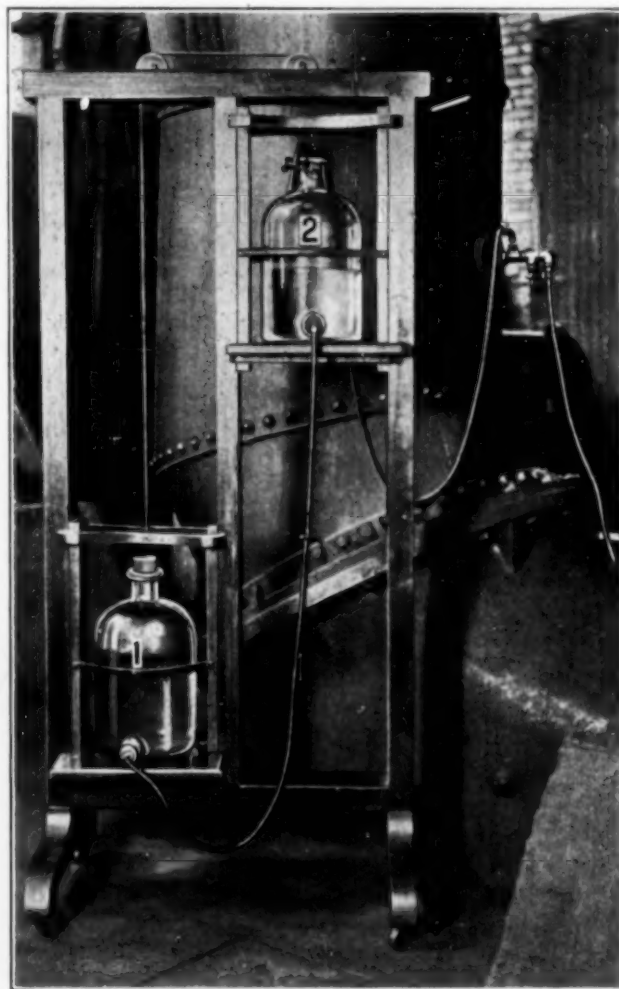


FIG. 2.—APPARATUS FOR THE SAMPLING OF GASES.

With the data of an analysis at hand, the explosion ratio for the first explosion is found by dividing the gas residue after Contraction II, by the sum of Contraction I and Contraction II, and the ratio for the second explosion by dividing the residue after Contraction III, by Contraction III. In the analysis of furnace, producer and flue gases, the most practical ratios of inert to the combining gases are those lying between 1.5 to 1 and 3 to 1; with producer gas the ratio obtained in the first explosion should approach as near as possible to the latter ratio, since the amount of heat liberated in the combustion of methane is relatively great.

Before beginning the analysis, it is advisable each day to agitate the bottle containing the oxygen and nitrogen mixture, and to flush out the connecting rubber tubing by lowering the leveling bottle (L), drawing in about 25 cc each of hydrogen

and oxygen and nitrogen mixture, and discarding through the three-way cock at the right. The solutions in the reagent pipettes are drawn flush with the main capillary tube, care being exercised that there are no unfilled spaces in the capillaries of the pipettes. The left half of the capillary is filled with water drawn over from the explosion pipette, the levelling bottle is now raised and any portion of the solutions that may have been drawn into the main capillary are expelled through the stem of the three-way cock at the right, to which is attached a piece of rubber tubing discharging into a suitable waste receptacle. While the levelling bottle is still raised the three-way cock is closed and in this manner the capillary tube is left filled with water. After the gas has been passed on the left side for absorption or explosion, or after the addition of each of the auxiliary gases, the capillary tube may be filled with water from the explosion pipette before a reading is taken, thereby avoiding the error due to the capillary space of 0.1 cc. The leveling bottle is placed at the base of the apparatus, and approximately 75 cc of hydrogen and 25 cc of oxygen and nitrogen mixture are added in succession, each being accurately measured by bringing the water in the leveling bottle to the same level as that in the burette. From a half to one minute should be allowed for the burette to drain before a reading is taken. The leveling bottle is raised and the cock leading to the explosion pipette (8) is opened, and the gas passed over and back two or three times to insure a thorough mixture, as an imperfect mixture may prevent the desired explosion.

The electric circuit is then closed causing the explosion. The bottle (Y), which receives the overflow from the explosion pipette, and the location of which on the lower shelf is never changed, the gases thereby being kept under partial vacuum, is connected to the latter by a piece of strong rubber tubing about 1 ft. long, partly constricted by a screw compressor near the bottle. The degree of the constriction is determined by increasing it until no bubbles appear in the pipette after an explosion. All the conditions of this arrangement tend to diminish the force of the resultant explosion.

After the explosion, the gas is immediately drawn back into the burette until the water from the pipette fills the left half of the capillary tube. The cock in the pipette is then closed, and after an interval of one minute for allowing the gas to cool, a reading is made. This less the previous reading represents the contraction due to the formation and condensation of water and is known as Contraction I. The oxygen that entered into the explosion is equal to one-third of the contraction, since



= liquid (disappearing).

$$\text{Percentage of oxygen in the mixture} = \frac{\text{oxygen and nitrogen mixture added}}{\text{oxygen found}} \times 100.$$

#### Example Data

	Burette Readings.	
	100.0	
Add hydrogen.....	74.6	Hydrogen added.
Add oxygen and nitrogen	25.4	
Mixture .....	25.2	Mixture added.
	.2	
Explosion .....	33.6	Contraction.
	33.8	
	11.2	1/3 Contraction or Oxygen found.

#### Calculations.

$$\frac{\text{oxygen found}}{\text{oxygen and nitrogen mixture added}} \times 100 = 44.4 \text{ per cent oxygen.}$$

Explosion ratio, 1.97.

Two or more determinations are made, which should agree within 0.1 per cent or 0.2 per cent. If there is question as to the accuracy of the results obtained, they may be proven by

using air as a standard, and subjecting it to conditions similar to those just described. It being known that there is 20.9 per cent of oxygen in air, it follows that if the oxygen factor as previously obtained is correct, the determined amount of oxygen in the sample of air should equal the theoretical.

The residue of gases from the previous analysis is rejected and about 60 cc of air are drawn into the burette and the burette is allowed to drain. The leveling bottle is placed on top of the apparatus, the tube leading from it is pinched tightly, and the three-way cock opened, the pressure of the gas being thus released. The remaining portion is slowly forced out by releasing the pressure on the tube until the meniscus just reaches the 50-cc mark in the burette, and the three-way cock is closed. When the leveling bottle is applied

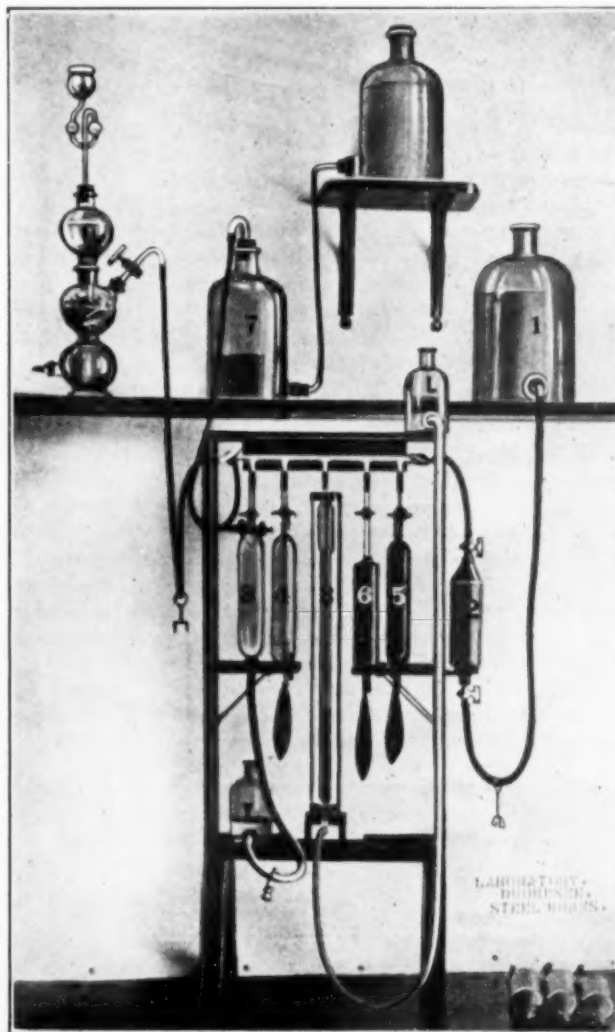


FIG. 3.—APPARATUS FOR THE ANALYSIS OF GASES.

there should be exactly 50 cc of air in the burette and to this approximately 20 cc of oxygen and nitrogen mixture, and a like amount of hydrogen, are added, a reading being taken in each case. The gases are mixed, exploded, drawn back into the burette and, after allowing one minute to drain and cool, Contraction I is noted. Hydrogen is then added until the volume of the mixture approaches 100 cc. The gases are again mixed and exploded, drawn back into the burette, and Contraction II is noted. It follows from the reaction previously stated that

$$\text{Total oxygen} = \frac{\text{Contraction I} + \text{Contraction II}}{3}$$

Oxygen in sample of 50 cc of air = total oxygen — oxygen added.

The result should approximate 10.45 and if so, proves the factor to be correct.



**Example—Burette Readings.**

Add Air.....	100.0	50.0 Air added.
	50.0	
Add Oxygen and Nitrogen Mixture...	20.0	20.0 O and N Mixture added (44.4% O <sub>2</sub> ).
	30.0	8.88 Oxygen added.
Add Hydrogen.....	10.4	19.6 Hydrogen added.
Explosion .....	39.8	29.4 Contraction I.
Add Hydrogen.....	1.0	38.8 Hydrogen added.
Explosion .....	29.6	28.6 Contraction II.

**Calculations.**

$$\text{Total Oxygen} = \frac{\text{Contraction I} + \text{Contraction II}}{3} = 19.33$$

Oxygen in sample of 50 cc of air = total oxygen — oxygen added = 10.45 cc.

Oxygen found in 100 cc of air = 20.90 cc.

Explosion ratios: I, 2.05; II, 2.46.

The percentage of oxygen may also be found from the same data; the oxygen in the mixture is the difference between the total oxygen found and that contained in the air used, the percentage is found by dividing the oxygen in the mixture by the volume of mixture used and multiplying the quotient by 100.

(To be concluded in the next issue.)

**Hooker Electrochemical Co. Works.**

We are glad to show in the accompanying illustration the plant of the Hooker Electrochemical Company at Niagara Falls, N. Y., for the production of caustic soda and chloride of lime by the Townsend electrolytic cell, which they purchased in the early stages of its development and have since perfected and successfully operated. It is a splendid example of concrete steel construction and is the result of the gradual expansion of the business since 1905. The company now ranks among the foremost producers of heavy chemicals in this country. In 1910 a portion of the plant was seriously damaged by fire, but was quickly replaced by construction of the most permanent character, and full operation was resumed early



NIAGARA WORKS OF HOOKER ELECTROCHEMICAL CO.

last fall. During the shutdown the company fulfilled its contracts for the delivery of material, waiving the rights secured to it by fire clauses in its contracts. This action is indicative of the broad business policy which the Hooker company has pursued since its inception.

The Townsend cell, which is comparatively simple and inexpensive both in construction and operation, has been successfully used in the mining industry to produce chlorine for

the chlorination of ores, and is recommended and licensed by the Hooker company for this purpose.

**Evaporators and Vacuum Pans.**

By B. VIOLA, M.E.

**The Kestner Evaporator.**

The principle of the Kestner evaporator is the climbing film and it introduces quite a novel condition in the evaporator business, having special advantages for the evaporation of delicate materials. Numerous experiments made have demonstrated that the liquor is in contact with the heating tubes for almost an infinitesimal time, thereby permitting the use of higher pressures without damage to the material, or lower pressures, thereby producing a material of high quality.

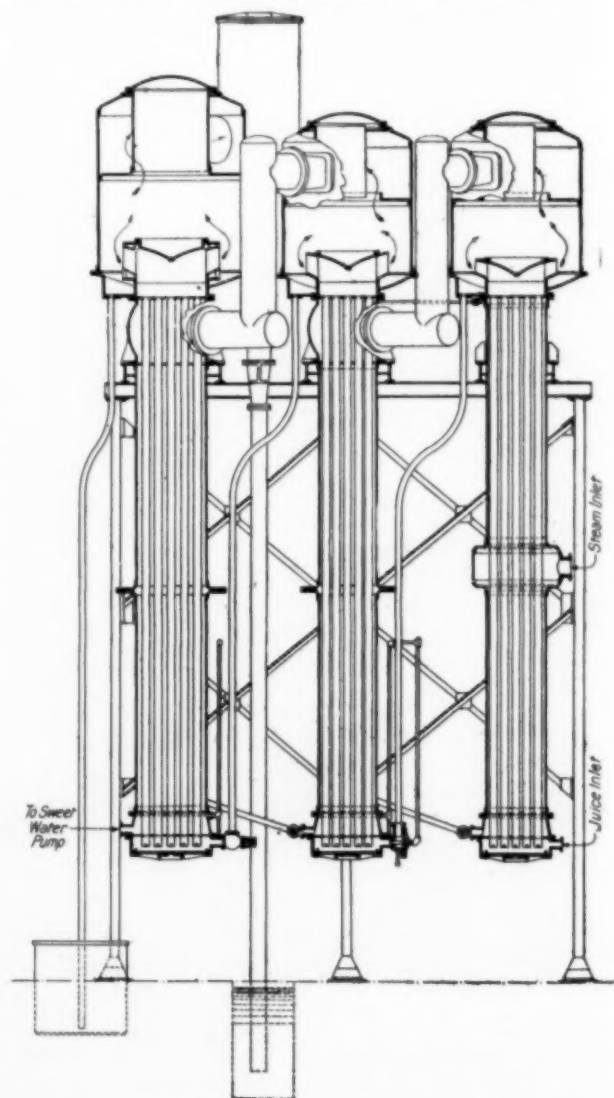


FIG. 29—KESTNER EVAPORATORS.

The liquid enters the base of No. 1 cell (Fig. 29). This should be fed in at a temperature approximating the boiling point in this body. The steam, as shown, surrounds the outside of the tubes, and as the liquor is at the boiling point it is, of course, ready to begin boiling at once. Small bubbles are formed at the base of the tubes, which readily grow larger until the entire core is filled with a solid mass of steam passing rapidly up the tube. The speed of this steam or vapor is such that it carries with it a thin film of liquid on the inside of the tube, and in virtue of the rushing steam this thin film is continually passing up and is pressed in close contact with the hot

walls of the tube. On reaching the upper tube sheet the mixed vapor and liquid pass through the so-called centrifugal separator, which consists of a series of curved blades having tangentially presented openings through which this mixture passes at high velocity. The liquid, in virtue of its greater specific gravity, is thrown farthest and is projected against the walls of the vapor belt or containing vessel. As this strikes these walls at an angle they impart to it a rotary motion,

liquor pipe between 2 and 3. The drawing, however, shows an angle valve which can be adjusted by hand.

The water of condensation from body No. 1 is ordinarily carried into body No. 2 and use is made of the thermal units set free in virtue of its higher temperature. In the same way the water of condensation passes from No. 2 into No. 3. As the steam belt of No. 3 is at a partial vacuum, the water of condensation must be removed by means of a pump.

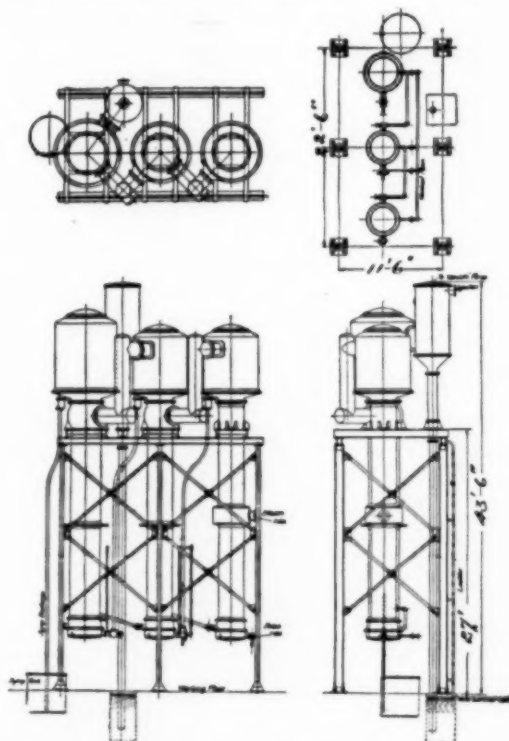


FIG. 30—TRIPLE-EFFECT KESTNER EVAPORATOR.

which further permits the complete separation of the vapor from the liquid. The major portion of the vapor, on account of its lower specific gravity, is not thrown so far as the liquid, and passes up at an intermediate point through the baffle or catchall, which forms the upper portion of the vapor belt. This catchall is arranged in the well-known manner and is inserted simply as a precautionary measure.

The vapor then passes through the vapor pipe between bodies No. 1 and No. 2 and enters the steam belt of No. 2, performing the same operation as in No. 1. The liquid, however, separated from the steam, passes down the pipe and through the automatic valve into the bottom of body No. 2, where the same operation takes place as in No. 1.

The automatic valve is a balance valve operated by a diaphragm. One side of the diaphragm is subjected to the pressure of the liquid in the pipe between bodies Nos. 1 and 2. The other side of the diaphragm is connected through what is termed the balance pipe with the steam belt of body No. 2. It is the practice to fill the vertical leg of this balance pipe with water. The hydrostatic head on one side of the diaphragm is, therefore, equal to the head of water in the balance pipe; and on the other side the head of juice in the liquor pipe. The pneumatic pressure on both of these columns is the same because steam belt No. 2 is at the same pressure as vapor belt No. 1. When these two hydrostatic heads are equal the valve is closed.

Should the head of liquor rise in the liquor pipe so that it exerts a greater hydrostatic pressure on its side of the diaphragm the valve will open and allow the liquor to pass until the hydrostatic head balances that of the balance pipe. In practice this valve remains partly open the whole time the evaporator is working. A similar valve might be used on the

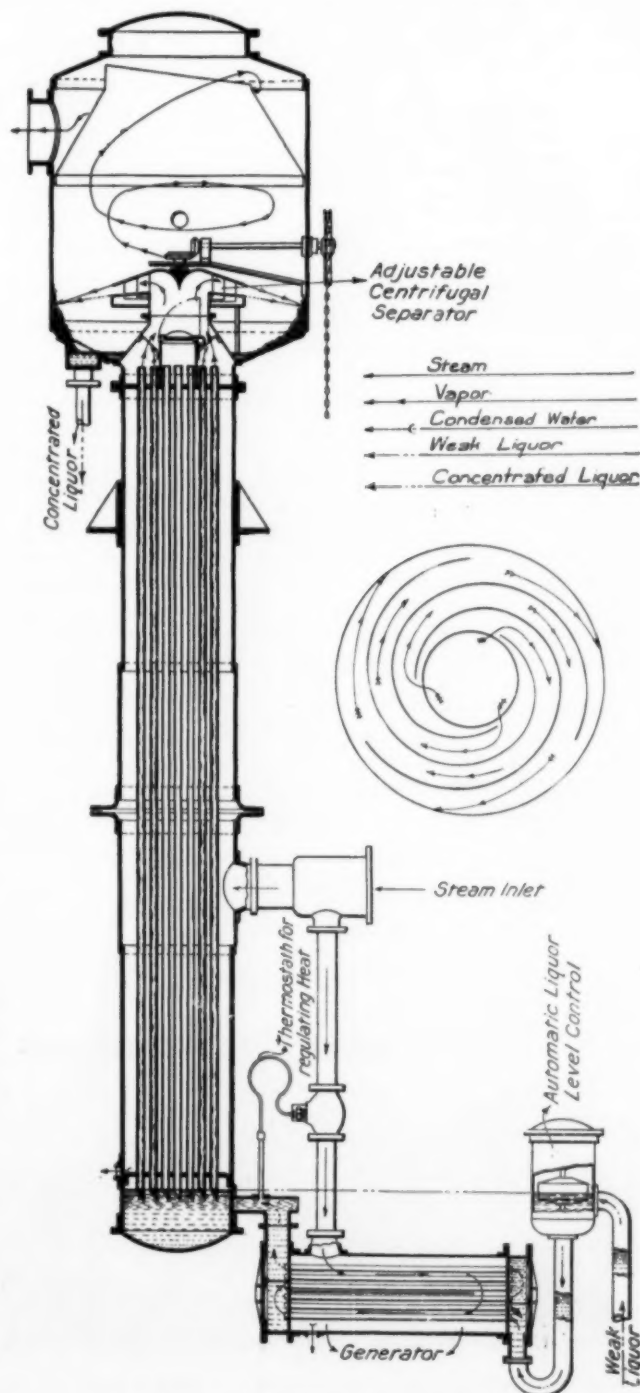


FIG. 31—JEDUN SYPHONIC FILM EVAPORATOR

The discharge of liquor from the last body takes place by virtue of the barometric height. The vapor from the last body passes into the condenser through the opening shown in the back of the last vapor belt. Fig. 30, the plan view of a triple effect, shows clearly the connection to the condenser.

#### Jedun Syphonic Film Evaporator.

As shown in Fig. 31, this evaporator's action, which has a

great similarity to the Kestner evaporator and works on the same principles, begins with a generator whose object is to generate a proportionate amount of vapor bubbles which enter the base of the evaporating tubes, carrying with them small pistons of layers of liquid which are contained in the expansion chamber. If the vapor bubbles are generated and supplied continuously the rising of the bubbles and layers of liquid will also be continuous within the evaporating tubes. The height

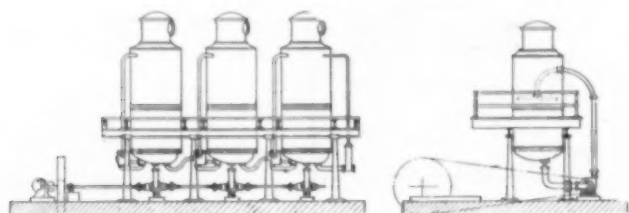


FIG. 32.—MEYER & ARBUCKLE'S REVOLVING DISTRIBUTOR ATTACHED TO A TRIPLE EFFECT.

to which the layers of liquid and vapor bubbles rise is governed by the amount and temperature of the liquid admitted to the expansion chamber.

The action of this evaporator is explained by the following: if a liquid and a vapor having the same temperature are allowed to rise in a current in small tubes the vapor bubbles, notwithstanding their lower specific gravity, will always rise through the tubes, carrying in front of them small pistons of liquid. Now, if the tubes which receive the bubbles of steam and liquid are surrounded by a heating medium, say steam of a temperature somewhat higher than the temperature under which the liquid or pistons of liquid and bubbles are to be evaporated, it is reasonable to say the evaporation of the liquid carried into the tubes by the vapor bubbles is very rapid, this depending upon the amount of vapor bubbles and liquid admitted into the tubes.

The vapor bubbles expand enormously and burst and the liquid evaporates owing to its contact with the heated surface of the tubes, which increases the volume of the vapor in a very large proportion, while the volume of the liquid decreases. As

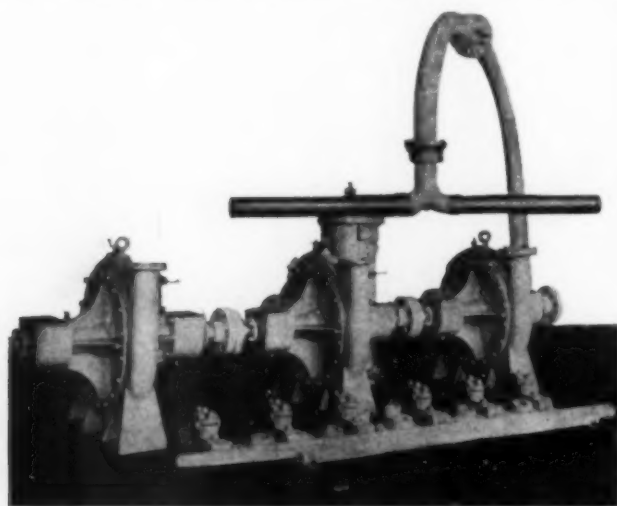


FIG. 33.—MEYER & ARBUCKLE'S REVOLVING DISTRIBUTOR CONNECTED WITH THE CENTRIFUGAL PUMPS.

the vapor in proportion is many times larger in volume than the liquid, this causes it to rush through the central portion of the tubes at such a velocity that it syphons or pulls with it along the heated walls of the tubes a thin film of liquid, which is discharged together with the vapor through an adjustable centrifugal separator into the vapor belt or chamber.

The action of this centrifugal separator is based on gravity,

centrifugal force and the converting of vapor bubbles into solid drops through causing them to burst by allowing the bubbles to expand from a higher to a lower temperature.

The vapor and liquid discharged from the evaporating tubes enter the centrifugal separator and by the arrangement of the centrifugal vanes therein have imparted to them a centrifugal motion, and also an increase in pressure or temperature through the adjustment of the head or cover of the separator. The average velocity of the vapor through the separator is from 80 to 120 ft. per sec., while the average velocity of the

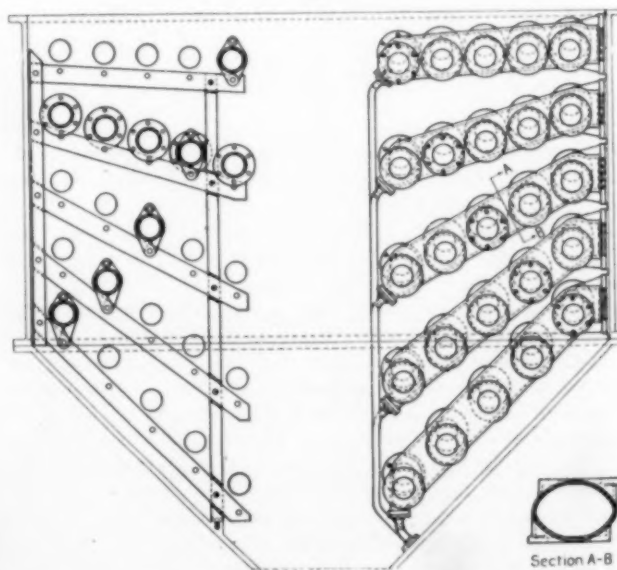
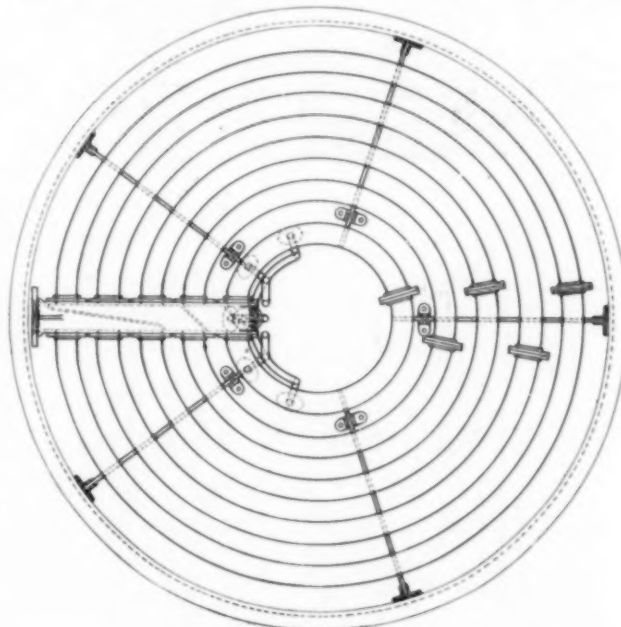


FIG. 34.—DYER MANIFOLD HEATING COIL.

vapor ascending in the vapor belt into which the separator discharges is  $3\frac{1}{2}$  ft. per sec.

The drops of liquid and vapor thrown off from the separator retain their original velocity. The drops of liquid being heavier than the vapor, combined with the centrifugal motion or force imparted to them by the separator vanes, and the downward angle at which they are thrown from the periphery of the separator, cause them to strike against the wall of the vapor belt, where they flow downward to the discharge pipe, while the vapor ascends free from all moisture and entrainment and passes on through the vapor main to the next effect or condenser.



Arrangements are made also whereby the evaporator can be worked at full, half, quarter or any capacity that may be required. To meet these varying requirements a hood is arranged encircling any given number of tubes. Thus the capacity is controlled at will.

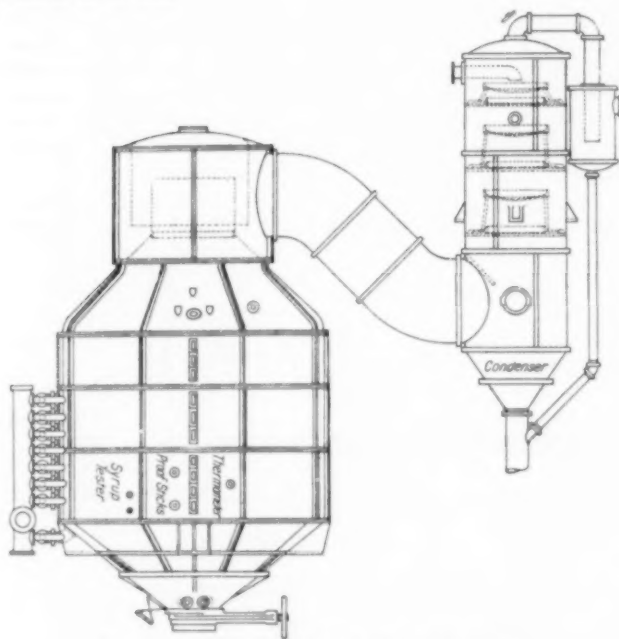


FIG. 35—DYER VACUUM PAN AND CONDENSER.

#### Meyer & Arbuckle's Film Evaporator.

This evaporator, or in other words, a film sprinkler, is a very original idea. It is in fact nothing else than an attachment to any evaporator with horizontal or vertical heating tubes. It is an automatic revolving distributor suspended over top tube plate in vessel, combined with centrifugal or other pumps for mechanical circulation, is the principle applied in obtaining an ideal film over the whole heating surface. Fig. 32 shows how it is attached to a triple effect, being provided with centrifugal pumps for bringing the liquid into the evaporator. The distributors, which are entirely automatic, are actuated by the escape of liquid through perforations in the arms bolted to the tee piece over the tube plate. The perforations in one arm are diametrically opposite to those in the other arm, thus there are no working parts beyond the ball bearings in the tee piece. The velocity is readily controlled by the increasing or diminishing angle perforations in relation to the top of tube plates.

Centrifugal velocity is imparted to the fine jets of liquor by distributors, resulting in a swirl down the interior heating surface of the tubes, leaving at the same time the center of the tubes free for rapid escape of vapors.

According to experience this attachment increases the efficiency of an evaporator 33 per cent (Fig. 33).

#### The Concentrating of Solutions Without Heat.

Experiments have been made lately for concentrating solutions without heating them, which process is based on the well-known osmosis. Vegetable membranes and artificially produced membranes of precipitates are known already which are semi-pervious, namely, which permit the solvent but not the dissolved crystalloids to pass through them. Numerous experiments made by A. Farago have demonstrated that most of the precipitates which cannot be dissolved in water or in other solvents possess the same property. In other words, they are semi-pervious, if prepared in a sufficiently thin layer.

The semi-pervious substances which are used in carrying out the process to which this invention relates are prepared as follows: Porous clay tubes, which can be closed at their edges, are filled with a solution of salt, one of the components of which is the component of the semi-pervious membrane to be produced. The tubes are then closed and placed in a bath which contains another solution of salt, one of the components of which is the second component of the semi-pervious membrane to be produced. The two solutions meet in the walls of the tubes and from there a new compound which in a finely divided condition fills the pores of the clay tubes. The tubes after being removed from the bath, emptied and washed out, will now be semi-pervious.

Now the essential novelty of this invention consists in the fact that the liquid to be concentrated is caused to pass through a system of tubes produced in the manner above described while a concentrated salt solution is caused to flow in the opposite direction around this system of tubes. If, from tubes of the character above described, there be constructed a system of tubes of sufficient length, surrounded by a second set of tubes made of glass, copper, stoneware, wrought-iron or any suitable material, and if the aqueous solution to be concentrated, be caused to flow slowly by means of a pressure pump through the inner of the two sets, while a concentrated salt solution is at the same time caused to flow in the opposite direction through the surrounding outer tube-system, there will arise between the two solutions an osmotic reaction through the semi-pervious clay tubes which will result in the passage of water from the aqueous solution into the concentrated salt solution.

As the two liquids flow in opposite directions it follows that the more concentrated liquid will gradually meet with the more

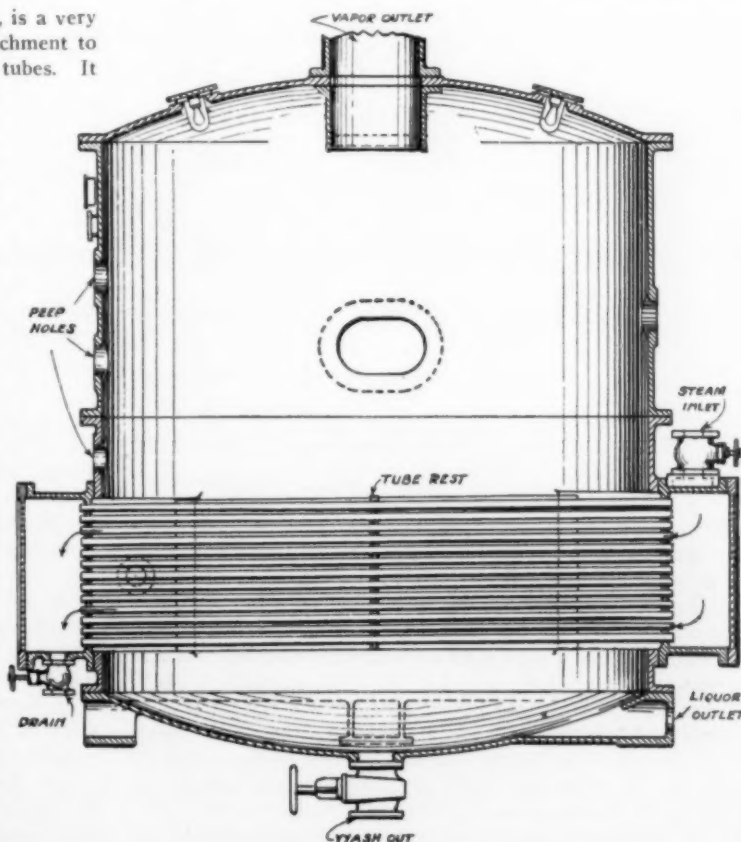


FIG. 35A—ZAREMBO VACUUM PAN.

concentrated salt solution, and as osmosis will continue as long as the two liquids differ in their degree of concentration the liquid to be concentrated will finally pass out of the tubular system with a degree of concentration corresponding to that

of the salt solution in the outer tubular system, while the salt solution used to effect concentration will pass out of the outer tubular system diluted to an extent corresponding to the dilution of the liquid to be concentrated.

The form of the tubular system used in carrying out the process may be of any desired kind, so long as it fulfills the condition of presenting as large surfaces as possible without taking up much room. The advantage of the process to which this invention relates, in comparison with those hitherto in use, consists in the fact that solutions which can be heated and evaporated only with a certain amount of risk, such as explosive substances or solutions which easily become decomposed when heated, can by means of this process be concentrated without any risk whatever.

This shows clearly that long heating coils will give hardly more than one-third of the efficiency compared with short, inclined tube heating systems. This is natural, for after steam enters the coils the condensing water will cover the lower part of the inner surface of the coil and the more it nears the end the more condensing water will be present. This water isolates the heating surface of that part of the coil entirely. Therefore the most efficient heating surfaces for vacuum pans should be made from short inclined tubes. By adopting this system, which has the advantage of greater economy and larger output in a shorter time, the present vacuum pans with long horizontal and vertical tubes will have to be reconstructed.

To improve this disadvantage of the heating-coil system, a very ingenious idea was worked out by a well-known Ameri-

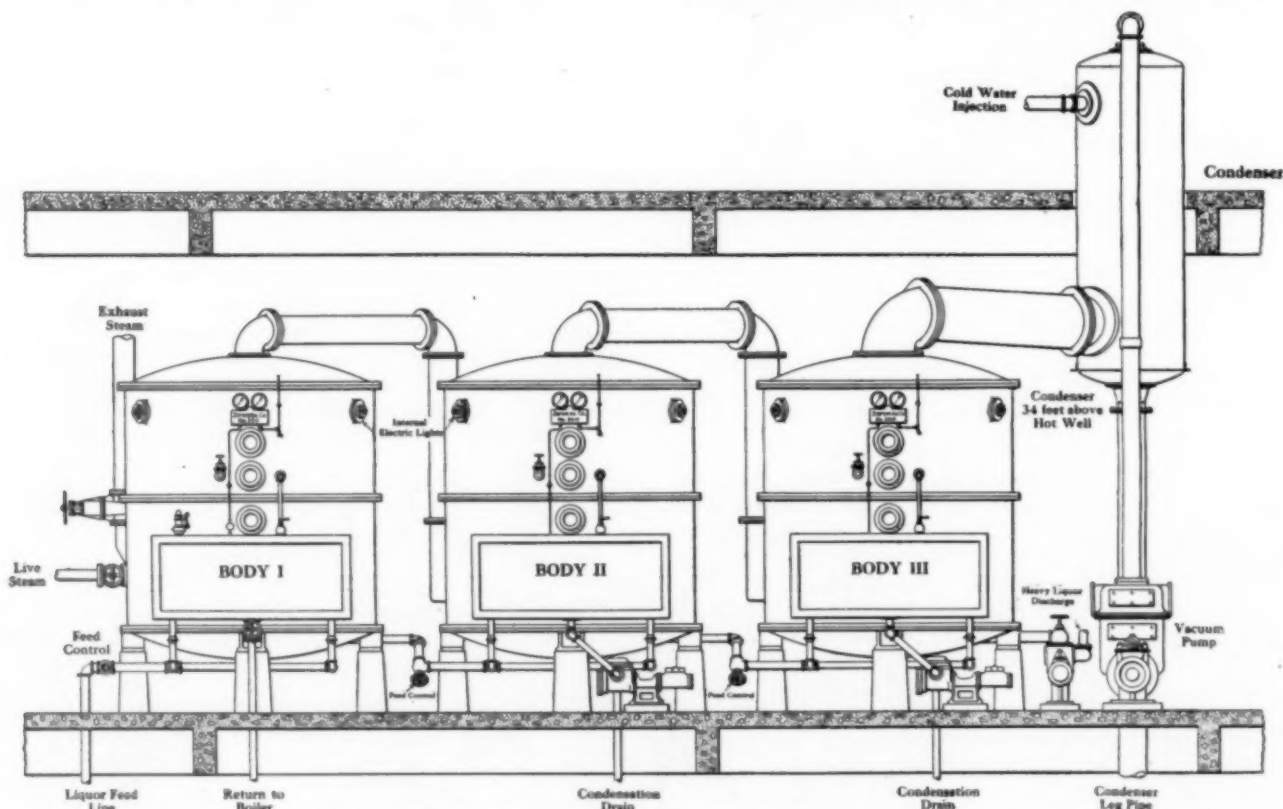


FIG. 35B—ZAREMBA TRIPLE-EFFECT EVAPORATOR.

Another advantage of this process, should it be practiced, consists in the fact that it is no longer necessary to employ complicated evaporation apparatus or to use fuel.

#### Vacuum Pans.

The vacuum pan is in fact nothing else than a single effect evaporator with the difference that in this apparatus is done the evaporating of the thick juice to massecuite in the sugar line. Formerly this process was effected in open kettles, which were treated by open fire or steam. Evaporation is produced now only in vacuum pans with the assistance of condenser and vacuum pumps.

It has been shown above how advantageous evaporation is by vacuum and low temperature. In vacuum pans mostly direct steam is used with higher pressure. Their shape is usually cylindrical and they are heated by heating coils, whose length is not more than 200 times the diameter. As mentioned before, the heating capacity of a heating coil is the largest where steam enters the coil, and decreases until it reaches the outlet. Researches inaugurated in the engineering laboratory of the Technical High School of Dresden by Dr. Eng. William Nusselt have led to the surprising result that the coefficient of transmission of heat is dependent not only on the difference of temperatures, but also on the length of the piping.

can vacuum pan building firm as follows: The manifold form of the coils is arranged in such a way that the number of pipes through which the heating system circulates is reduced from time to time, and this is in proportion to the estimated reduction in volume, so that the velocity of the vapor is maintained, as is also the pressure in all parts of the heating system (Fig. 34).

One of the most modern improved vacuum pans supplied with the heating coils shown in Fig. 34 can be seen in Fig. 35. This is a Dyer vacuum pan, 16 feet in diameter and equipped for live and exhaust steam heating, and is connected with a very efficient barometric counter-current condenser. There the drips or drains from all heating coils are connected to two manifolds outside of the pan.

One manifold, called the "live steam drip manifold," receives the drain water from all coils which at any particular time may be using live steam. The exhaust steam manifold in the same way receives the drains from the coils which are using exhaust steam. The water of condensation from the live steam drip manifold flows by gravity to a closed receiver, from which the boiler feed pump delivers it directly into the boilers without loss of temperature due to reduction of pressure. The drain from the exhaust steam manifold is handled in the same

way by a separate receiver and pump. The total heating surface of this pan is 2280 sq. ft., it has a juice catcher in the top and a very suitable connection to the condenser.

A cylindrical vacuum pan, with horizontal heating tubes is shown in Fig. 35a. This is the Zaremba system, with cast steel; it is also built of steel, copper or other metal. The heating surface is made of seamless drawn tubing of copper, brass, steel, etc., as the conditions may demand. The tubes are all of one length and are secured in place by an improved type of elastic packing that is absolutely tight and at the same time is easily taken out when the tubes are to be removed. Sagging of tubes at the center, in large machines, is prevented by the use of a tube rest. Steam chests can be so arranged as to make possible a large increase in heating surface whenever desired, by merely inserting additional tubes.

The steam circulation is from right to left through the tubes, which are rapidly drained of their condensation by being given ample incline. Liquor circulation is upward around the tubes and downward through large segment-shaped downtakes between the tube nest and the sides of the evaporator. Both steam and liquor circulation is very rapid, thus yielding a great efficiency of the heating surface.

The steel structure is simple, with only three readily kept tight joints; no internal bracing is required and yet an internal pressure can be carried with perfect safety. The bottom plates are so designed as to give either much settling space under the tube nest, or no such space, as may be desired.

The vapor space above the tube nest is made high and is so arranged that its entire volume is efficiently used to prevent entrainment loss. As an additional safeguard against entrainment the pans are equipped with an internal separator which returns to the liquor body any liquor particles that may have escaped with the vapor.

This construction (Fig. 35b), combined with a multiple effect, is used with excellent result as an evaporator.

(To be continued.)

### Pittsburgh Meeting of American Foundrymen's Association

While going to press this year's convention of the American Foundrymen's Association and allied societies is still in progress in Pittsburgh. The attendance is again enormous, and it may be stated that there are an unusual number of chemists, metallurgists and assayers in attendance. In the following we give brief notes on some of the papers presented.

#### Standard Test Bars for Cast Iron.

Dr. RICHARD MOLDENKE, the untiring secretary of the association, presented a memorandum on standard tests for cast iron.

At the Copenhagen Congress of the International Society for Testing Materials the so-called "arbitration test bar for cast iron" was fully discussed, and comparisons made of the practice prevalent in the several interested countries of the world. The test bar in question is  $1\frac{1}{4}$  in. in diameter, and 14 in. long, being broken transversely on supports 12 in. apart.

The comparison of the practice showed that so far as the diameter of the bar is concerned there is a general accord. Germany, Italy and the United States have adopted to  $1\frac{1}{4}$  in. diameter, or metric dimensions very close to this. England, while quite favorably inclined, has not yet acted officially on the subject.

Further, the manner of preparing the test bar seems to be in accord everywhere in its main features. Bars are to be cast on end, in dry sand. Germany differs only in pouring from bottom up, whereas all the other countries pour directly into the top. German practice is undoubtedly the better one, though more expensive.

The radical difference in the several standards seems to lie

entirely in the length of the bars for test. We break at 12 in. between supports. Germany makes it almost two feet, while Italy takes the distance only six inches. It was, therefore, suggested at the Copenhagen Congress that a series of tests be made in the several countries interested, with bars ranging from six to twenty-four inches between supports in breaking them, and from the results obtained that length be selected which will give the best all-around values.

Mr. Walter Wood, of R. D. Wood & Company, the chairman of the Commission on Cast Iron, took up this work for the United States, and reported at the last meeting of the American Society for Testing Materials. Both transverse and tensile tests were made. One set of the transverse tests would indicate a steady downward progression of the modulus of rupture for cast iron, as the span increases. But from the results so far obtained the need has become evident to extend the series of tests to smaller spans, say as low as 6 in. With the results extended over spans from 6 in. to 20 in. it would be possible to plot a curve showing the relation of the span to the modulus of rupture of the material, the turning point being found when too great a stiffness and consequent high results change to too great a weakness, or possible lack of sensitiveness on the part of the test, on the other side. This point, when found for the several classes of iron at issue, would be the desirable length of the span for a standard test.

#### Foundry Coke and Foundry Chemistry.

Mr. H. E. DILLER, as secretary of the company, presented a set of the proposed standard methods for determining the constituents of foundry coke. This will be published in full in one of the next issues.

An instruction paper on foundry chemistry by Mr. HERBERT E. FIELD gave definitions of entectics and segregation, and discussed the effect of phosphorus on cast iron.

#### The Electric Furnace for Steel Castings and General Foundry Work.

This interesting subject was discussed in a brief note by Dr. PAUL HÉROULT.

At the present time some of the Héroult electric furnaces are busy on steel castings; in fact, some are exclusively erected for that purpose; for instance, at the Fischer Steel Foundry, Schaffhausen, Switzerland; Lake and Elliot, Baintree, England, and out of forty others in operation most of them are intermittently employed for castings, as for instance, at Worcester and South Chicago. The steel is perfectly sound, of high quality, and is good and hot when cast. It is so dead when poured that they do not need to increase the percentage of silicon and they run 0.15 and lower.

This, however, has been proved long ago. A more interesting feature of the electric furnace is that it is capable of improving the quality of foundry iron, and this at very low cost and by a very simple operation.

The main feature of what is called strong iron is the low content of sulphur. The removal of sulphur is one of the easiest and most effective operations that can be performed in the electric furnace. It consists simply in pouring into the furnace a charge of molten pig iron, if possible direct from the blast furnace; if not, from a cupola or other melting apparatus, then heating the metal under a basic slag which does not have to be scraped or removed except when it is teemed into a ladle with the metal ready for pouring. The contents in carbon, silicon, manganese and phosphorus are not affected by this operation unless this be desired. Common Bessemer iron, worth anywhere from \$10 to \$14 per ton can be changed into strong iron, charcoal iron, carwheel iron, or so-called cold-blast charcoal iron for a cost of about \$1 per ton.

It seems probable that on account of the high grade of material so cheaply produced most iron castings of the future will be made of this improved quality. This new improved product will help to give new life to the iron foundry industry and will enable it to compete with the steel-casting industry.



### Titanium in Iron.

The effect of titanium in iron was discussed in a paper by Mr. CHARLES V. SLOCUM, of the Titanium Alloy Manufacturing Co. The gist of the paper is contained in the following conclusions: Very small percentages, as low sometimes as 1/10 of 1 per cent (0.1) of alloy (only 0.01 Ti), are sufficient to cleanse the iron of impurities not touched by limestone or fluor-spar, while larger percentages increase the improvement in other directions, making the iron more fluid (usually hotter), making the castings sharper, finer grained, free from blow-holes and pin-holes, and easily machined, while at the same time the expense runs from 25 cents per ton of castings up to say \$3 as a maximum, all of which is often repaid in the reduction of bad work and in improving poor irons.

### Manganese and Silicon in the Foundry.

A paper by Mr. ALEXANDER E. OUTERBRIDGE, Jr., deals with the use of manganese and silicon for foundry purposes. With respect to manganese he referred to the long series of his investigations with this element in connection with the special kind of cast iron used for making chilled cast iron car wheels. Formerly such wheels were made entirely from cold-blast charcoal iron, but this was replaced by the author's manganese treatment in the ladle. (*Jour. Franklin Institute*, March, 1888.)

Mr. Outerbridge points out that manganese acts in two different and opposite ways in cast iron.

When alloyed therewith in the cupola in considerable quantity, say 2 per cent or over, it has a chilling and hardening effect, producing what he terms a spurious chill of coarse crystalline nature, in contradistinction to the normal chill in a good car wheel which has a fine and closely interwoven crystalline structure.

When the alloy ferromanganese is added in a ladle of molten car-wheel iron in small quantity (1 pound of alloy, containing about 80 per cent manganese, in 600 pounds of iron), it acts not as an additional contribution of 0.133 per cent manganese to the metal in the ladle, but simply as a deoxidizing and desulphurizing flux, cleansing the metal from impurities, softening it and greatly increasing the ductility and strength without injuring the chilled tread of the wheel.

In view of these two directly opposite effects of manganese the author thinks that the ignorant and improper use of ferromanganese in general foundries is sure to lead to disappointments.

While ferromanganese is best adapted to the treatment of high chilling iron for carwheels or chilled rolls, or other chilled castings, where the proportion of combined carbon is large, on the other hand ferrosilicon is best adapted to treatment of foundry iron when from any cause it is hard and brittle, since it possesses the peculiar property of softening and at the same time strengthening such iron. It also enables the founder to vary the grade of iron in individual ladles to suit individual castings or groups of castings. It gives the founder control of his iron after it has been withdrawn from the source of melting, a matter of great importance and value, and it enables him to use cheaper grades of iron.

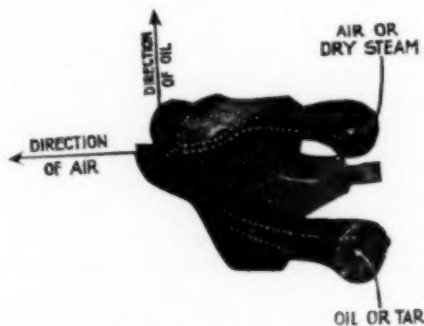
But neither ferromanganese nor ferrosilicon can be regarded as universal panaceas, and while each in its proper place is of great value, they must, like all other good things, be used intelligently, and if impure adulterated materials are employed they will not only prove to be of no benefit but must be absolutely harmful.

### Oil as Fuel for Air Furnaces.

Mr. W. N. BEST pointed out that, according to analysis, oil has a much higher calorific value than coal, and therefore ought to be able to melt the metal in a much shorter period of time than coal. Further, when oil is used as fuel the castings contain no more sulphur than the metal did when charged into the furnace, and the tensile strength is consequently greater than of metal melted by coal fire. As the melter has the

furnace under perfect control the heats can be taken off much quicker than while burning coal, and the temperature of the charge while being tapped can be maintained without varying more than 25° Fahr. until all the charge has been run from the furnace.

The change from coal to oil is said to be a very simple matter. In the original firebox he constructs a combustion chamber of such form and proportions that the air necessary for perfect combustion can unite with the atomized fuel before it



USE OF OIL FUEL FOR AIR FURNACES

reaches the furnace, which prevents oxidation of the charge. Also this chamber causes the heat to be deflected upon the entire surface of the bath.

In the end of this combustion chamber he places a hydrocarbon burner of peculiar form, which makes a fan-shaped blaze, filling the entire chamber with flame. This burner exteriorly atomizes any gravity of liquid fuel which will flow through a 1/2-in. pipe, such as fuel oil, crude oil and tar. Its construction is such that it cannot carbonize, and there are no parts to wear away or get out of order.

A very small quantity of compressed air is used through the burner to atomize the fuel and distribute the heat, while the balance of the air necessary for perfect combustion is supplied at from 3 to 6 oz. pressure through a volume air nozzle.

The furnace is charged in the usual manner. The burner is started by opening the air valve, holding a piece of burning waste (which has been well saturated with kerosene) by means of a pair of pick-up tongs under the burner, and then turning on the oil.

The reduction in the time required to get the charge ready for tapping is not the only point wherein oil is more economical than coal. There is no handling of fuel and ashes, consequently the service of the fireman and coal passers are dispensed with. There is great saving in floor space for the oil tank is placed underground and the former coal bins used for other purposes. The fire brick lining of the furnace lasts 20 per cent longer than with coal. Poor castings or imperfect ones caused by the metal being cool or sluggish are obviated entirely.

This method is used by the Barlow Foundry Company, in Newark, N. J., and the Malleable Iron Company, Oriskany, N. Y.

### Cupola Melting Practice.

A paper by Mr. P. MUNNOCH dealt with various phases of cupola practice, with special reference to British practice. A few points were considered more in detail.

One of these is oxidation during melting. There are two effects which result from oxidation, one of which is the reduction in the amount of silicon and manganese during melting, the other is the oxidation of the iron. The amount of oxidation depends largely upon conditions of melting.

Dr. Moldenke has pointed out that the method of using large charges in the cupola is the chief cause of this trouble, and by reducing the size of the charges and therefore preventing any great variation in the height of the coke bed above the tuyeres this oxidation is prevented.

A charge of below two hundred pounds per square foot of cross sectional area might be considered a small or suitable

charge and a charge above this amount is called a large charge.

The lower the melting ratio and the lower the density of the coke, the smaller the charge desirable. Therefore, in some cases one hundred pounds per square foot sectional area might be ample.

Other special points discussed in the paper are the total coke ratio, the changes occurring during melting, the removal of the sulphur, and the action of slags in regard to oxide in metal. The author considers the use of limestone in the slag as useful for removing oxygen from the oxidized iron.

As to the limestone requirements of the cupola charge the author considers the fact that in the cupola slags seldom contain more than one part of lime or two parts of silica to be a suitable basis for calculation. This leads to the rule that equal weights of limestone to silica in the components of the charge used will give suitable amount to add, after making allowance for silica from lining.

Generally the amount required will vary between thirty and sixty pounds per 2000 pounds of iron.

#### Gas Cavities, Shot and Chilled Iron in Iron Castings.

This subject was discussed in a long paper by Mr. THOMAS D. WEST, of Cleveland, Ohio.

The reason of the creation of the small, hard particles or metal shot found in some castings is that they become suddenly separated from the general mass of metal during the pouring of a mold. When thus separated they solidify so quickly that not sufficient time is given for the carbon to be separated out as graphite. Hence the shot does not have the softness of the rest of the casting which had more time to cool.

The longer the distance a shot is sent through the air before it lodges and the cooler the air it passes through, the harder the shot. Affecting this, also, is the degree of dampness of the spot upon which the shot may lodge. Where shot is caught and covered by incoming metal before it has time to become cooled below a red heat the chances for their being hard and discoverable in a casting are not, of course, nearly as great as when they can become of a dark color before being encased by the liquid metal.

Particles of iron or shot may be formed during the falling of the metal from the ladle's pouring lip by striking the sides of a pouring basin or gate. Again, by falling upon a flat bottom inlet gate. Or when the metal, reaching the mold, strikes some obstruction fronting the gates to splatter the metal. In ordinary plain work there is probably no feature so harmful in causing a splattering as having flat-gate bottoms. The bottom of all pouring gates should be more or less of a well, as by this formation, if there is hesitation for a moment or so when starting to pour, the first droppings from the ladle fall into the well, to say there is a liquid bulk and not be splattered to create shot.

In starting to pour the majority of molds, especially those of a light work and stove-plate character, there should be no momentary stoppage for starting, but from the instant the falling metal first strikes the bottom of a gate there should be a steady and unbroken stream to rapidly fill the pouring gate, and have it kept so until the mold is filled. This applies to the flat-top pouring gates generally used for stove plate, etc., as well as those of the joint character.

The too free use of a swab or sponge in wetting the joint of a mold, before drawing a pattern, or after this is done in finishing a mold, can easily harden or chill the metal parts of a casting formed where this excessive dampness existed. Again, also, by too damp a mixture of sand hard ramming or insufficient venting. Metal striking these damp sections will often bubble and splatter to a greater or less degree. This action can in some cases create suddenly chilled shot that will be carried to other sections of a mold to become encased in liquid metal and thereby give the white iron or chilled shot found in some castings.

The author next discusses globules in gas cavities and blow-

holes. These defects can be due to two conditions, but emanating from one cause, and that is the creation of excessive gases or steam that cannot find its liberation from imprisonment within a body of solidifying metal. They are found chiefly in the upper body or cast end of castings.

Excessive gas, causing blow holes or cavities, may come directly from the metal or wholly from defects in molding or pouring. Those due to the iron may be caused by oxides of iron or manganese reacting on the iron's carbon, the former producing carbon monoxide gas, or on liberated graphite creating kish (although of the latter there is a very little in remelted iron, it being chiefly found in direct metal at blast furnaces). Also indirectly through sulphur, by reason of the formation of sulphide of manganese.

And again by a foreign body like that possibly created by the mixture of iron oxide and dross (the latter may contain some kish in connection with the dirt generally coming from clays of the cupola tap hole and spout, and other sources) forming a slag on the top of a ladle's metal that could pass in small bodies into a mold at the starting of pouring, or later on before a mold is filled, through defective skimming. Thereby often large as well as small blow holes or gas cavities are formed.

As a side issue it can be said that a ladle's surface dross can easily cause dirt holes, pin holes and a dirty surface to the finish parts as well as the rough surface of castings when skimming is at fault in pouring a casting.

Gas cavities and blow holes due directly to defects in molding and pouring are often due to not having properly tempered sand, regulated degrees of hardness in ramming, efficient means of venting and correct methods of finishing cores and molds, combined with needed experience in grating and pouring. These are all factors demanding the experience of a decade or more in the actual work of general molding.

Molding machines, owing to the following of an exact routine adopted after much experimenting as the best to insure desired results, cannot but be helpful to a large degree in removing the liability of stream and gas cavities, or blow holes, chargeable to molding.

The author then discusses methods of deciding whether globules are due to defects in metal or molding. Sulphur and phosphorus causing blow holes are said to be a weak excuse for defects.

The work of Mr. P. Munnock, of the British Foundrymen's Association, is then discussed. The present author attributes the defects cited by Mr. Munnock to the molds.

The present author's contention that the molds are more responsible as a general thing than the iron for the creation of blow holes, etc., is not to be taken as meaning that there is nothing to be feared by gases that may emanate directly from some irons.

The author briefly discusses the use of alloys for dioxidizing and purifying iron and finally discusses the very rare and mysterious occurrence of "inside chill," or white iron inside of gray or soft iron.

#### Electricity in the Foundry.

A paper by Mr. BRENT WILEY, of Pittsburgh, Pa., on "Electrical Applications in the Foundry," gives some interesting and valuable figures on the electric power requirements of foundries with a capacity of 1500 to 2000 tons per month. The figures are based on the experience of a number of modern foundries of this size with electric drive throughout, and equipped with overhead traveling cranes in each department. The weight of the castings range from 100 to 100,000 pounds, with an average of 250 pounds. The electrical equipment was 220-volt, direct-current, with one exception, which included 400-volt, three-phase motors. The average conditions for these foundries are as follows:

Floor motors, one 75-hp air-compressor, one 20-hp cold saw, two 30-hp sand mills, eight 5-hp grinders, six machine-shop

motors of together 50 hp, one 25-hp repair-shop motor, six miscellaneous motors of together 58 hp. Total, 323 hp.

Crane motors, two of 50 tons each (280 hp), three of 25 tons each (250 hp), four of 10 tons each (180 hp), two of 5 tons each (90 hp). Total, 800 hp.

Crane hoist motors. Total, 400 hp.

A general rule for power-house capacities is that the average load will be approximately one-half of the total capacities of floor motors and crane hoist motors. In figuring the crane load on the power station it is to be noted that as the hoisting motion of the crane gives the heaviest load, and as it is seldom that more than one motion is used at a time, it is sufficient to consider the load on this motor only. As the crane work is very intermittent the load is very fluctuating, and the total capacity of power generators should not be less than twice the average load. As a general rule a spare generating unit will prove a paying investment to insure ample power at all times.

For the above conditions the average power house load is  $723 \div 3 = 241$  hp =  $180\frac{3}{4}$  kw, and two 175-kw generators would be sufficient.

Or, figured on another basis, it requires approximately 35 kw hours per ton of steel castings, and approximately 45 kw hours per ton of iron castings, for foundries ranging in capacity as given above. The blast for the cupolas of the iron foundry and the greater amount of small work increases the electric power per ton output.

The values given for power-house capacities include power for lamps and other auxiliaries, such as electric welding for the steel foundries, repair shop and pattern shop.

The following general conditions for foundries, as mentioned above, have been established. The capacity of the floor or constant-speed motors is approximately equal to the capacity of the crane hoist motors.

The average station load equals one-half the total capacity of floor motors and crane hoist motors.

The maximum station load equals approximately twice the average load.

The average distance for distribution of power is 600 feet or less.

The applications of varying-speed motors are few except where considerable machine work is done, in which case the power required will seldom be over 15 per cent of the total station capacity.

The lighting load will average from 10 to 12 per cent of the total load.

As to the question of direct current versus alternating current the author points out that for the small plant, with a power station capacity of 300 to 500 kw, and an average distributing distance of approximately 600 ft., the 250-volt, direct-current system offers many advantages. Direct-current motors can be used for all the applications.

However, if a foundry has its own power plant the cost of generating power is high on account of the rapidly fluctuating load. It is doubtful if the average steam power plant of the foundry, under the most favorable conditions regarding price of fuel, etc., can produce power for less than 2 cents per kw-hour, and for the majority of the plants the cost will be even higher.

A central station, being of large capacities, would not feel the direct effects of the load fluctuations. The load, being practically continuous, improves the load factor. Thus, to the small plant, especially, the central station companies can often offer good inducements to purchase power.

Lighting is the principal load of the central station, and the system mostly adapted is 60-cycle, alternating current, which offers decided advantages regarding economy of distribution of power. In the case of an existing plant having direct-current motors installed, a rotary converter could be used to convert the power to direct current of suitable voltage.

If the proposition relates to a new plant then a more economical plan will be to use the alternating current direct, although in

a majority of the cases it will be necessary to reduce the voltage. Usually the transmission voltage will be over 1000 volts, and transformers should be used to give 240 volts for distribution within the foundry.

Considerable discussion has taken place between the electrical engineers of the iron and steel industry during the last two years regarding the most suitable voltage for inner works distribution, and from a safety standpoint it has been decided that 240 volts for 220-volt, alternating-current motors, and 250 volts for 230-volt, direct-current motors should be used, and these voltages are becoming standard for this class of industry.

The alternating-current, squirrel-cage, wound motor offers several advantages over the direct-current motor for the floor machines, with the exception of the applications requiring varying speed, such as machine tools, and for these applications it would be best to instal a small motor generator set to give direct current.

#### Lifting Magnets in Foundries.

The application of lifting magnets for foundry service was discussed in a paper by Mr. H. F. STRATTON, of Cleveland, Ohio. While the lifting magnet has found very extended application in the steel industry, and is also used largely by the railroads for handling their scrap material, the foundries have been reluctant to introduce it.

However, to prove the adaptability of the lifting magnet for foundry work the author gives the following estimate of cost for a foundry melting 35 tons of metal daily, 300 days in the year. The cost of the magnet and crane installation, with a lifting capacity of 1350 pounds of pig iron, is \$4,000. A crane and a magnet of this size can handle 35 tons per hour at an operating cost (wages, fuel, oil) of 48 cents per hour, or 1.4 cents per ton.

The annual depreciation on the \$4,000 equipment at 12 per cent would be \$480, and as 35 tons handled twice per day for 300 days represent 21,000 tons handled annually the depreciation cost on this tonning basis is 2.3 cents per ton. This brings the total cost of handling, including wages, fuel, oil and depreciation, up to 3.7 cents per ton.

The author is told by a gentleman well versed in foundry practice that 10 cents per ton is a fair figure to assume for the cost of loading or unloading pig by hand, and on this basis the saving would be \$1,323 annually, or 33 per cent on an investment of \$4,000.

To sum up, a foundry melting 35 tons of metal daily can install both a crane and a magnet, and expect a return upon the investment, after allowing all charges, of more than 30 per cent. If it happens that a foundry is already equipped with either an electric or locomotive crane a magnet can then be installed on a very profitable basis when the tonnage to be handled is considerably less. For instance, if an assumption be made that a foundry melts 20 tons daily, and that a magnet be installed on an existing crane, the cost of the magnet being about \$900, then the cost of handling, per ton, including wages, fuel, oil and depreciation on the magnet, is about 2.3 cents, which would represent a saving in this foundry of about \$924 each year, or more than 100 per cent on the investment.

"It is very earnestly hoped that these figures be not brushed aside with the assumption that they are theoretical and must be largely discounted. As a matter of fact, the costs of handling by a magnet are stated conservatively, and are being bettered in service daily."

Handling scrap, in general, will be more expensive than handling pig iron, whether it be done by hand or by magnet, but the advantage in favor of the magnet is more marked in the case of scrap than in the case of pig.

#### Efficiency.

"The Efficiency Movement in the Foundry" was discussed in a paper by Mr. C. E. KNOEPEL. He emphasized two conclusions from practice: That a man can accomplish considerably more than he does, and that the management, as business is at



present conducted, does not know what constitutes the best a man can do.

It is necessary to build up an effective organization from the bottom upwards. This requires a constructive type of organization that erects on a firm foundation and in a scientific manner a structure that will consider the various elements entering into making the enterprise successful. These elements are: (1) The man. (2) The work to be done. (3) The conditions under which he does his work. (4) The planning of the work he has to do. (5) Reward for individual effort. (6) The records affecting the factors of the business. These six different items are discussed in succession.

#### Brass Founders' Association.

##### Bronzes.

A paper by Mr. JAMES R. HUBER, of the Lumen Bearing Company of Buffalo, N. Y., on the analysis of manganese bronze gave an account of some improvements on the method described in this journal, August, 1910. The complete paper by Mr. Huber will be published in one of our next issues.

A paper by Mr. C. P. KARR gave results of determinations of the pouring temperatures of various bronzes under foundry conditions, and on the use of the pyrometer, especially the radiation pyrometer, in the foundry.

##### Non-Ferrous Foundry Economics.

A paper by Mr. E. A. BARNES, of the Ft. Wayne Electric Works of Ft. Wayne, Ind., gave interesting and concise notes on refinements in non-ferrous foundry installations and operations. He discussed the design of the building, heating and ventilating systems, office, pattern storage, metal storage, sand bin, crucible storage, core oven, welfare work, power plant arrangements, meters, air compressor radiators, etc.

In the matter of furnaces, ladle heaters, scrap-recovering furnaces, enormous saving can be effected by intelligent handling. With the old system of coke and hard coal pit furnaces, which of course are adhered to for many kinds of production, the greatest injury done to the crucibles is from the rough handling with the tongs and the uneven heating and cooling. With the fuel oil system and tilting furnaces, which are becoming more and more popular, combined with the propagation of suitable reducing flame in a combustion chamber of sufficient volume and absolute control of temperature, this crucible loss is greatly reduced.

One of the greatest items of loss in a brass and aluminum foundry is the shrinkage. This is occasioned in many ways. Poor system is responsible for all of them. Volatilization loss in the methods of melting is the most important.

In their furnace they employ the concentric burner, using compressed air at about 35 pounds per square inch to pulverize to a mist the fuel oil which is supplied at about 25 pounds pressure at the nozzle. This fuel oil and atomizing air are both preheated by proper arrangements before they issue from the burner.

The volume air for combustion which is supplied through a truncated nozzle surrounding the concentric portion is maintained at about 8 ounces pressure and by valves and gates both the compressed air and fuel oil and the volume air are controlled, maintaining the "reducing flame" whether a slow or a fast fire is desired.

It is very necessary to have absolute control of combustion in order to produce the reducing flame, otherwise at these high temperatures the oxygen of the air will combine with the free graphitic carbon and other components of the crucible and furnace lining and very rapidly disintegrate the same through chemical combination, and the metal itself will suffer loss and injury through oxidation.

**Ladle Heaters.**—Their ladle heaters, which are arranged to use the same burner, are made with a telescoping hood that is raised up when the pouring crucible is introduced and then dropped down enveloping the same. In this way the crucible is evenly heated. These ladle heaters are very useful for get-

ting out small batches of work, as the heat generated in them can be as high as that produced in the larger furnaces.

**Conservation of Heat in Spent Gases.**—On visiting any foundry one is struck with the enormous amount of apparent lost heat and energy that issues from the vents. This heat, in the form of spent gases, can be utilized for many useful purposes if proper arrangements are made in the design of the foundry to conserve them. Core ovens can be heated, as can also wash water for use in the lavatories; these are two of the most important. The preheating of air and oil is another. This, of course, involves piping and arrangements which may to some appear complicated and unnecessary, but they are nevertheless well worth taking into consideration.

**Scrap Melting Furnaces.**—In a manufacturing industry like the one with which the author is connected they get skeleton brass from the punch press department, borings and turnings from the machine shop in large quantities each day. The regular practice is to run these through an efficient magnetic separator connected with a blower system which takes out the iron, paper and light particles, passing the good metal into bins. In place of selling this stuff to the junk dealer at prices depending on varying conditions they save and separate these borings, etc., and use them in their foundry at once.

The copper and red brass borings are taken to the melting floor and are used up with gates, sprues and new metal. Much of this stuff, however, is of a mixed nature and cannot be so handled; it is therefore taken to the scrap melting furnace and run into ingots. These ingots are analyzed by the chemist, who determines closely their components. These ingots are further alloyed with pure copper and other new metals in varying proportions and first-class metal for all general purposes produced from them.

They also handle in their scrap melting furnace copper wire which they get from burned-out field coils, armature coils and scrap generally that is known to contain pure copper. The resultant pigs are analyzed and used as base copper for more important mixtures. The furnace is cleaned out, skeleton brass, borings, yellow brass, etc., are run off and stored.

With their scrap melting furnace they developed an endless chain arrangement for carrying the chills. The contents of these chills are automatically dumped into water, which cools, cleanses and softens the metal simultaneously. This system involves the continuous melting and pouring principle which they have found in practice to be preferable to the "hot bath" system where the metal is melted and tapped out into crucibles and repoured. This does not, however, indicate that the "hot bath" system is not better adapted to some other foundry requirements.

As to the actual runs of scrap and the losses incident to the recovery of the same the following figures are given:

Bare copper wire: Total wire melted, 9054 lbs.; total ingot recovered, 8888 lbs.; loss or shrinkage, 166 lbs., or 1.83 per cent.

Fine wire (includes burning off of insulation): Total wire melted, 3089 lbs.; total ingot recovered, 2773 lbs.; loss or shrinkage, 316 lbs., or 10.24 per cent.

Yellow brass punched scrap: Total scrap melted, 3000 lbs.; total ingot recovered, 2860 lbs.; loss or shrinkage, 140 lbs., or 4.5 per cent.

**Aluminium.**—In their aluminium department for years they had been using the open-flame form of reverberatory furnace and were always confronted with a heavy loss amounting often to 6 3/4 per cent. Their aluminium work is of a peculiar nature—light and of an odd pattern. For every pound of casting they produced they had to pour one pound for the runners and one pound for the riser or header. They therefore only received 33 1/3 per cent net of the gross metal melted. The loss, therefore, had to be multiplied by three, making 20 per cent net. They figure gross weight, because they charge so much metal to the melting floor, making a bi-monthly inventory of the castings turned over to the factory and the metal in the form of ingots, sprues and risers remaining over.

They could not see any immediate relief from this loss, so carried on experiments from time to time and finally decided that a tilting furnace similar to their regular crucible furnaces, but arranged with an iron kettle of the proper dimensions and shape, was the solution.

With this new type of furnace they are able to handle the same number of pounds of aluminium per heat as with the old open-flame furnace with a loss of only  $2\frac{1}{2}$  per cent gross, as it eliminates entirely the losses due to the cutting action of the flame. In the iron kettle the flame does not touch the metal at all and while the time employed in getting out the first heat is necessarily longer, it does not materially affect the total output.

Another great advantage in the kettle type of furnace is that the slag and oxide which form on the top of the pot act as a protection of the metal, and the spatter, skimmings, etc., instead of being thrown into the scrap pile, are returned to the melting pot, where the globules of metal held in suspension in the slag separates from the slag and mix with the metal below, the slag itself remaining on top in the form of a protecting blanket.

In the melting of their metals such as aluminium they employ pyrometers. They have found by using these instruments that the overheating of the metal is avoided.

A great economy results from the pre-alloying of metals. In alloying aluminium and copper it is a well-known fact that the copper, which melts at a much higher temperature than the aluminium, must be melted first. The aluminium is then added, combines with the copper and through chemical action the temperature is liable to rise to a point that vaporizes off much of the aluminium.

To rob this phenomenon of its most harmful effects they have made a practice of compounding a rich alloy of half and half copper and aluminium, which they throw into pigs. The copper is melted first and the aluminium is added in small quantities, allowing the temperature to gradually reduce with each addition of aluminium, thus preventing overheating any considerable quantity of metal. This rich alloy, which now necessarily melts at a very much lower temperature than the original copper, is used in the final compounding of their aluminium mixture. All risk of overheating or mis-mixing large and individual batches is thus eliminated. Not only this, but the remelting has a refining effect and a much better product is insured.

The use of fluxes, such as phosphor tin, baron, magnesium, etc., is much more effectively carried on under the direction of a chemist who makes a special study of the action of these fluxes on the metals. The author is convinced that the employment of a chemist or foundry chemical engineer in a foundry of any size soon pays a handsome dividend on his salary. As a rule the practical foundryman has too many other things to attend to in producing to spend much time in developing.

#### Alloys.

A paper by Dr. W. R. WHITNEY, director of the Research Laboratory of the General Electric Company, called attention to the possibilities in the way of useful discoveries, which may well lie more nearly within reach of some of the foundrymen than they realize, because of their particular knowledge or possession of special materials. These discoveries should be made by the more extended use of the "more recent metals," particularly in the manufacture of alloys.

Dr. Whitney thinks it highly improbable that the cost of copper will ever be greatly changed by the discovery of new uses. On the other hand, with aluminium it is still possible that considerably wider uses and reduction of production costs may develop in its future.

Dr. Whitney then gave an interesting, concise résumé of those elements which only recently have come into commercial use.

The element *calcium*, which a few years ago was listed only as museum specimens and at several dollars per gram, was sold

in 1908 at \$1.50 per pound, and could certainly be sold for a small part of this price if a greater use could be found for the metal. It slowly decomposes water, giving hydrogen, and it differs from the alkali metals in producing such a feeble alkaline solution that it is generally harmless. It ought to serve as a good deoxidizer, and should be a very cheap metal. It is not fair to relegate it to a list of useless metals. History of the metallic arts points to there being no such list.

*Thallium* is an element quite similar to lead, but probably possessing some property which will some day warrant its exploitation. It is softer and heavier, and could be obtained in quantity if a demand were created.

The elements *chromium*, *molybdenum*, *tungsten* and *tantalum*, the three latter now obtainable in wire-form, are tempting elements to study in mixtures with others. Who knows the useful properties of a chromium bronze, for example?

*Tellurium* has long been an apparently useless metal, and any market price is fictitious, as there is but little isolated in metallic state. It is not necessary that a great use, such as a substitute for zinc in brass, should be found for it. Our industries are so great that if a pound of tellurium added to the ton of aluminium was of benefit to the latter the production of the necessary tellurium would be real industry.

Consider *cobalt* a moment. The world's rate of supply of ore has been greatly augmented. It may take time to actually realize a greatly reduced cost of metallic cobalt, but we ought, notwithstanding, to realize it when uses have been developed. Our natural impulse in such a case is to try direct substitution of one metal for another in some well-developed use. Cobalt, for example, might replace nickel in most uses when the cost fell below that of nickel, but this is a second order use. A first order use would be the supplying of a want which no metal previously supplied, or supplied distinctly less perfectly.

In this connection an interesting alloy of cobalt and chromium has just been developed by Elwood Haynes, and it is altogether probable that technical use will soon be made of it. (See our Vol. VIII, p. 652.)

Many tons of metals are annually consumed as resistance wire for electrical purposes. At one time iron was the element most used. German silver replaced it in some cases, where a lower temperature coefficient was needed and the increased cost was permissible. Now there are a dozen or more special alloys for this particular electrical use. The new ones have far out-classed the old in most of those properties for which the electrical engineer uses them. In such alloys nickel, chromium, manganese and others are now used by the ton.

*Silicon*, which in 1900 was a curiosity and sold for 40 cents per gram, is now a necessary component of special iron alloys and of high-grade transformer iron, and the world uses thousands of tons of the alloy annually. Silicon is now sold at about 5 cents per pound. The use of this metal in other alloys is still quite limited. In the case of iron, it greatly decreases hysteresis loss and increases electrical resistance.

*Boron*, still a quite expensive material in metallic state, is coming into commercial use in assisting the making of solid copper castings of high electrical conductivity.

*Vanadium* seems to be a young wonder-working metal. Its use has increased very rapidly in the past few years, but the quantities consumed are not known to the author. As several companies are producing the iron alloy it is safe to assume that it is being sold by the ton. The price for the metal in the alloy is not far from \$5 per pound.

*Cadmium* is a beautiful metal in many respects, and it is certainly awaiting use. It is whiter and less crystalline than zinc, and doubtless the high price of nearly a dollar a pound keeps practical workers from trying it in their experiments. It should be produced as cheaply as aluminium, if there were a good demand for it.

*Titanium* is an element long the subject of criminal negligence. It is a high-melting, ductile, white metal, which, at present, is only separable from its ores at high cost. It exists in



many cheap ores widely distributed in nature. It is now apparently coming into use in steel manufacture, particularly for railroad rails, and for this purpose it is fortunately unnecessary to isolate the pure titanium from its ores, an iron titanium alloy being produced directly. What will happen when the pure element has been tried in special field can only be surmised. The optimist sees great chances. The pessimist feels himself busy living with the optimist.

If one omits the common alloys, brass, bronze, solder, etc., and considers only possible alloys of two metals, and still confines himself to 20 of the common metals, like vanadium, manganese, chromium, boron, etc., he is interested at once to recognize that there must be one hundred and ninety different pairs of binary alloys. When, in addition, the effect of varying proportions in these alloys is considered, it becomes evident that the field of alloy research is truly a large one. Many of the alloys apparently unstudied are those which melt at extremely high temperatures.

The brass founder who knows the upper limiting temperature of his melting furnaces may at once point out that this temperature is fixed both by the life of crucibles and the particular coke or oil-heating schemes with which he is familiar. If he thought that a molybdenum bronze of 86 per cent molybdenum would have useful properties compared with all other alloys he might at once conclude that he must give up this alloy because of the difficulty of melting it.

If it were not for the advances in our available temperatures there would seem to be little more than amusement in considering alloys high in tantalum, in chromium, in titanium, in molybdenum, in silicon, in uranium, in vanadium and a number of other high-melting metals, but hand in hand with the discoveries leading to isolation of such metals go also discoveries of aluminothermics, oxyacetylene and oxyhydrogen temperatures and electric furnace processes.

The time is always ripe for the study of new alloys with new tensile strengths, elasticities, colors and wearing powers. The automobile and the aeroplane have forced the aluminium and iron alloys to make rapid strides, and it is natural that we should want to inventory our possibilities.

The physical chemist has started along the way of a systematic co-ordination of certain properties of binary, and in a few cases tertiary alloys. He has shown how to plot a few freezing points of two-metal and three-metal mixtures and to construct therefrom curves showing not only all possible metals but what may be expected in the way of segregation and structure and such effects as caused by annealing or quenching.

He has found that there is a solubility of metals in one another which varies just about as the solubility of substances in water varies. Metals may be melted together and well mixed, but the quality and permanency of the mixture is determined by just such solubility laws as control ordinary solutions. We know that in some cases well-mixed melted metals will separate into two layers if allowed to remain even a few moments in molten condition at low temperatures. Such a pair are zinc and lead. They act like a mixture of water and ether. The two separated layers contain both metals, no matter what the temperature, but the quantitative compositions depends on the temperature.

The other extreme of metal solubility is found in such a case as zinc-cadmium, which acts much like a mixture of alcohol and water, the two components going into solution in all proportions and remaining in solution at all temperatures. Having seen this analogy between the facts of solubility of substances in water it is natural to search among the metal mixtures for all the peculiar kinds of solution observed in aqueous solutions.

Two such classes interest us at once. They are those corresponding to aqueous solubilities where temperature widely influences the quantities dissolved, and those in which the solvent (as water) combines with the dissolved substance more intimately than by simple solutions, as by chemical combination. In the case of zinc and lead we have one of the metal alloys

of limited solubility. If these two metals are well mixed in liquid state they separate into layers—one, the zinc, carrying a few per cent dissolved lead floats on an alloy made up of lead carrying a few per cent of dissolved zinc. In general, the quantity of the one metal dissolved and held in solution by the other depends on the temperature, and the higher the temperature the greater the solubility. Between 900 and 1,000 deg. C., they are apparently completely soluble. It follows from this that when a dissolved pair of metals is cooled slowly one of them may separate on cooling, if the limiting solubility is reached, and the extent of effective separation may depend on the rate of cooling.

Our second case, that of chemical combination between the metals, is made most evident by the form of the freezing point curve of the possible alloys. A compound of two metals which is stable at a temperature above the melting point of one or both of the metals shows very clearly on the melting-point curve and acts towards each of the elements just as a new or third element. Its melting point cannot be predicted from any knowledge of the component metals. It may even melt higher than either of the components. Such cases are seen in alloys of aluminium-antimony, in lead-tellurium, etc.

Man first used the metals as he found them; then, as he reduced them from the ores, and finally, when specified requirements became more and more exacting, he not only brought into use previously unused metals, but also greatly modified the old familiar ones. For a harder iron he used steel, a carbon alloy; for a harder steel, or one capable of cutting iron more readily, he added tungsten, nickel, chromium and other metals. For permanent magnets molybdenum was added, for high electrical resistance nickel, chromium, etc., were added; for low electrical hysteresis, silicon and aluminium were added; for toughness in springs a little vanadium was used, and for wearing qualities titanium is now introduced. These are only a few of the successful alloying experiments with iron. They will probably be repeated with other metals, such as copper, zinc, and aluminium, where the cost of the base metal is not high.

On the other hand, the study of those metals which have not yet advanced to a stage where first order cost reduction is impossible, is equally interesting. Consider again the element chromium. What do we know about it? Is it a workable metal? Can it be hammered or cast? Is it permanent in the air? Is there a considerable possible ore supply? Has the cost of obtaining the metal been reduced to what seems a reasonable rate? etc., etc.

As it is unlikely that such an element will suggest itself for use by men as did copper and iron, it is probable that its properties must first be determined and made known. As a metal it is only about fifteen years old. It is made in the metallic state by reduction of the oxide by metallic aluminium and also by electrolysis of its salt solutions. It cannot yet be produced at a lower cost than that of the aluminium required, and it now sells at about 80 cents per pound. In the oxide from which it was made it may be had for less than half this cost, and in its alloys with iron, which are made by direct reduction with carbon; it is sold for 29 cents per pound. This gives a rough idea that ultimately, by perfection of metallurgical processes, etc., we may possibly obtain the metal much below 80 cents per pound.

It withstands heat exceedingly well. When pure it melts at very high temperature (Ostwald, about 3000 deg. C.) and it does not scale when heated red hot in air, as copper and iron do. It is for this reason that it is used in resistance alloys for electric heating devices. It has been plated onto metals, and then looks and acts like nickel plate. Doubtless its use will quite rapidly increase in special alloys, as it has already come into use in tool steel.

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In the following we give an incomplete alphabetical list of the exhibitors at the sixth annual exhibit of the Foundry and Mining Exhibition Company held in connection with the Foundry



drymen's Association convention. This exhibition was really an immense affair and all the exhibits were looked over with greatest interest by the visiting foundrymen.

The Adams Company, Dubuque, Iowa.  
Albany Sand & Supply Company, Albany, N. Y.  
American Vanadium Company, Pittsburgh, Pa.—Vanadium cast steel and cast-iron specimens.  
Arcade Manufacturing Company, Freeport, Ill.  
Atlas Car & Manufacturing Company, Cleveland, Ohio.—Storage battery locomotive, new type sand-blast car, portable track and side-dump sand car.  
Jonathan Bartley Crucible Company, Trenton, N. J.—Crucibles, retorts, stoppers and a variety of graphite specialties.  
Carborundum Company, Niagara Falls, N. Y.—Carborundum and aloxite grinding wheels, carborundum fire sand and carborundum rubbing bricks.  
Chicago Pneumatic Tool Company, Chicago, Ill.—Franklin tube G. C. B. compound belt, driven air compressors, improved Keller sand rammers, tripod sand sifter, pneumatic geared wire rope hoists, Boyer-Keller chipping hammers, electric grinder, side spindle electric drill, Little Giant pneumatic grinder and castings cleaner, Chicago Universal hose coupling.  
The Chisholm & Moore Manufacturing Company, Cleveland, Ohio.—Chain hoists, trolleys, hand-power traveling cranes and malleable castings.  
Cutler Hammer Manufacturing Company, Milwaukee, Wis.—Lifting magnet adapted for foundry use.  
The Deming Company, Salem, Ohio.—Hand and power pumps, white-washing machines.  
Joa. Dixon Crucible Company, Jersey City, N. J.—Crucibles for both brass and steel melting, special shapes and formulas for various purposes, phosphorizers, stirrers, skimmers, stoppers, nozzles, sleeves, etc.; graphite refractories, foundry facings, motor brushes and graphite products.  
Stanley Doggett, New York City, N. Y.—Foundry specialties, parting compounds, manganese dioxide, soapstone, graphite facing, facings, powdered charcoal, dioxide of manganese flux, ferro-manganese, ferro-silicon, iron and steel cement, metal workers' soapstone, crayons and pencils.  
Electric Controller & Manufacturing Company, Cleveland, Ohio.—Lifting magnets and controllers, automatic motor starters.  
General Electric Company, Schenectady, N. Y.  
Goldschmidt Thermit Company, New York City, N. Y.—Full line of metals produced free from carbon, heating thermit cans, titanium thermit cans, thermit welding process and appliances.  
Harbison-Walker Refractories Company, Pittsburgh, Pa.—Ordinary shapes and standard cupola blocks in fire brick.  
Hauck Manufacturing Company, New York City, N. Y.—Oil-burning appliances, including cupola lighters, ladle heaters, core oven and furnace burners, mold dryers, preheating and brazing outfits.  
Hawley Down-Draft Furnace Company, Chicago, Ill.—Metal melting furnaces.  
Ideal Furnace Company, Chester, Pa.—Brass melting furnaces.  
Ingersoll-Rand Company, New York City, N. Y.—Twelve-inch stroke "NE-1" air compressor, pneumatic chipping, caulking and scaling hammers, pneumatic riveting hammers, sand rammers for bench and floor work, pneumatic motor hoists, pneumatic stationary motors and pneumatic piston and rotary drills.  
Monarch Engineering & Manufacturing Company, Baltimore, Md.—Latest improved furnaces using oil or gas as fuel for melting and heating, Acme core oven, steel foundry ladle, heating equipment, aluminum furnaces, Allis' "Eclipse" bolt-heating furnaces, blowers, etc.  
Northern Engineering Works, Detroit, Mich.—Type E electric crane trolley and joint exhibit with Cutler Hammer Manufacturing Company, Milwaukee, Wis.  
Norton Company, Worcester, Mass.—Grinding wheels, alundum and crystolon, abrasive materials, India oil stones, crystolon sharpening stones, Norton alundum refractories consisting of small electric furnace parts, cores, tubes, muffles, crucibles, combustion boats, filtering dishes, etc., for laboratory use.  
Thomas W. Pangborn Company, New York City, N. Y.—Sand-blasting machinery.  
Pittsburgh Steel Foundry, Pittsburgh, Pa.  
Pittsburgh Valve Foundry & Construction Company, Pittsburgh, Pa.  
Rockwell Furnace Company, New York City, N. Y.—Centric pouring crucible furnace.  
Rogers, Brown & Company, Cincinnati, Ohio.—Pig iron, coke, ferro manganese "Rosiclar" floor spar.  
Shepard Electric Crane & Hoist Company, Montour Falls, N. Y.—Trolley for three motor electric traveling crane with cage, including the controllers, cage controlled electric traveling hoist and back-geared electric motor.  
The W. W. Sly Manufacturing Company, Cleveland, Ohio.—Miniature display of Cleaning mills, cinder mill and dust arrester and sand-blast equipment and machines.  
J. D. Smith Foundry Supply Co., Cleveland, Ohio.  
Frederick B. Stevens, Detroit, Mich.  
Tate, Jones & Company, Inc., Pittsburgh, Pa.—Brass crucible furnace, oil pumping, heating and regulating system, oil burners, portable burner for ladle drying and cupola lighting.  
Taylor Instrument Co., Rochester, N. Y.—Recording pyrometer, radiation pyrometer and other small instruments.  
United States Graphite Company, Saginaw, Mich.  
Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa.—Motors and controllers for direct and alternating current and variable speed work.  
Whiting Foundry Equipment Company, Harvey, Ill.—Standard heavy duty exhaust tumbler with steel plate barrel and lever type door fastener, spur-gear crane ladle, with standard gear cover, worm-gear crane ladle, truck for crane ladle, standard turntable.  
J. B. Wise, Watertown, N. Y.—M. R. V. brass-melting furnaces, tilting type, permanent crucible using coke as fuel.  
Yale & Towne Manufacturing Company, New York City, N. Y.—Hand and electric hoists with trolley running on I-beam.

**Resistance Wire.**—A recent British patent (14,743, March 30, 1911) of the British Thomson-Houston Company (General Electric Company of this country) refers to an alloy which can be rolled and drawn and which is suitable for resistance wire or heating elements. It consists of twenty parts by weight of iron, sixty-two parts nickel, twelve and one-half parts chromium, five parts manganese, and between 0.1 per cent and 0.4 per cent of carbon. This alloy oxidizes only very slowly at a red heat. (London *Elec. Eng'g*, April 6.)

## Electrodeposition of Copper Free from Arsenic from Electrolytes Containing Arsenic

The effect of organic and inorganic "addition agents" upon the electrodeposition of copper from electrolytes containing arsenic is the title of a thesis submitted by Mr. CHING YU WEN, to Columbia University, for the degree of Ph.D.

The investigation is interesting in two respects. First, it has a distinctly practical bearing on copper refining, and, secondly, it is of interest in connection with the problems of the action of addition agents in electrolysis which originated on a large scale with Mr. A. G. Betts in his lead-refining process. They have been studied quite extensively, especially by Dr. E. F. Kern, of Columbia University, under whose direction the present research was also conducted.

In the production of good pure copper by electrolysis, the composition of the electrolyte is one of the important factors. The cause of poor copper is chiefly due to the impurities which accumulate in the electrolyte and which, under usual conditions, are precipitated along with the copper. Of those impurities the most harmful and troublesome ones are arsenic and antimony, the presence of which in the deposited copper makes it brittle and nodular.

It has been a known fact that during electrolysis part of the arsenic and antimony contained in the anode dissolves and remains in solution. These two elements, especially the arsenic, are allowed to accumulate in the electrolyte till a critical point is reached, which has not yet been definitely determined. When this point is passed they begin to be deposited with the copper on the cathode and render the deposit bad and brittle.

To prevent this it is therefore of utmost importance to maintain the electrolyte within a certain degree of purity, in other words to keep the amount of arsenic and antimony in the electrolyte below the critical point. This is usually accomplished in practice by withdrawing a certain portion of the electrolyte and replacing it with an equal quantity of fresh solution, and the copper in the impure electrolyte is recovered either by crystallization or by electrolysis with insoluble lead anodes. This not only complicates the process of electrolytic refining of copper, but also entails an extra item of expenditure in the production of electrolytically refined copper.

Another thing that is observed during the electrolysis is that "sprouts" or dendritic "trees" often form, especially along the edges of the cathode. The formation of such "trees" interferes with the work, renders it more difficult to operate and prevents the electrodes from being placed together, as there is danger that the electric current would be short-circuited. In conducting the electrolysis in a commercial way, the removal of these "trees" becomes absolutely necessary and is usually done by the tank inspectors, thus increasing the cost of refining.

The object of Dr. Ching Yu Wen's investigation was, therefore, two-fold; first, to prevent the deposition of arsenic and antimony on the cathode, and second, to prevent the formation of dendritic "trees." This problem was worked out, having in mind the production of solid and smooth deposits, from copper electrolytes containing high percentages of arsenic, by means of organic and inorganic "addition agents."

Dr. Ching Yu Wen's thesis is quite voluminous; first abstracts of former literature relating to the subject are given and then his own experiments are described in great detail. For the description of the apparatus and details of the results the reader must be referred to the original thesis. In the following we give the chief conclusions.

The experiments as performed may be grouped under four main headings: (1) Impure electrolytes, which contained no "addition agents." (2) Impure electrolytes, which contained inorganic "addition agents." (3) Impure electrolytes, which contained organic "addition agents." (4) Impure electrolytes, which contained organic and inorganic "addition agents."

(1) With electrolytes which contained no "addition agent" much arsenic and antimony was deposited with the copper, even

when the electrolytes contain 1.5 per cent arsenic. With electrolytes containing 2 per cent and 3 per cent arsenic a still greater amount of these two impurities were deposited with the copper, and large dendritic "trees" also formed on the surface of the deposits. These impurities rendered the copper dull colored and brittle.

At temperatures between 50° C. and 60° C., and with electrolytes containing over 6 per cent arsenic, the arsenic acid appeared to act as an "addition agent," as it prevented, to some extent, the deposition of the impurities (arsenic and antimony) with the copper and also retarded the formation of dendritic "trees." At temperature of 40° C. and below, however, this action of arsenic as "addition agent" in the electrolyte did not appear to take place in the electrolyte containing under 6 per cent arsenic, whereas in the electrolyte containing 8 per cent arsenic the deposited copper was purer, brighter, more solid and coherent, and less brittle.

This shows that the good effect of arsenic acid depends not only upon the temperature of the electrolyte, but also upon the amount which is present in the electrolyte. This phenomenon cannot be explained from the data obtained in these experiments, but it may be attributed as the result of the hydrolization which converts the arsenic sulphate  $As_2(SO_4)_3$  into arsenous acid  $H_3AsO_3$  and sulphuric acid  $H_2SO_4$ . The reaction is  $As_2(SO_4)_3 + 6H_2O = 2H_3AsO_3 + 3H_2SO_4$ .

Temperature and the amount of arsenic in solution both appearing in this case to be functions of the reaction. As the arsenic is in the form of an acid radical, it would not be precipitated on the cathode, but would act as a reducing agent in the electrolyte and thereby give results similar to those of the ordinary "addition agents."

(2). Hydrochloric acid, sodium sulphate, aluminium chloride and sodium chloride, all, when present in small amounts, have a distinct action upon the improvement of the deposited copper both chemically and physically. They cause the deposits to become more or less smooth, dense, pure and free from "trees."

Of these inorganic "addition agents" the best and most effective is sodium chloride, hydrochloric acid to a slight degree. The effect of sodium sulphate is still less; it produces little or no effect if present in too small amounts, especially at temperatures of 40° C., and when the electrolyte contains 3 per cent arsenic.

Aluminium chloride, though it improves the copper deposits, to some extent, does not seem to be a suitable "addition agent," while aluminium sulphate is, on the other hand, a satisfactory one, it causing the copper to deposit low in impurities and more ductile.

From the results of the trial of inorganic "addition agents" it appears to be true that the salts of those metals, which stand by far higher in the emf series than copper, are generally satisfactory "addition agents." They possess the property of preventing, to a considerable extent, the deposition of arsenic and antimony and the formation of "trees." The latter action of inorganic "addition agents" is difficult to explain, but, according to Dr. Edward F. Kern,\* it is due to the reducing effect of these metals (in ionic state). The higher that the metal of the "addition agent" stands in the emf series the purer, smoother and less brittle the deposit appears.

Temperature plays an important part in the electrolysis of copper. With higher temperature the ductility of the copper seems to be increased and the potential between the electrodes decreases. In the case of sodium sulphate as "addition agent" with higher temperature it becomes more effective.

(3). In the case of organic "addition agents," both gelatine and tannin produce a remarkably beneficial effect upon the copper deposits and are satisfactory "addition agents." The presence of gelatine at the beginning of the electrolysis has the effect of causing the formation of small fern-like "trees," but after operating for a period of time the deposits are smooth and ductile. Peptone, unlike gelatine, exerts a detrimental influence

on the deposits and, therefore, is an unsatisfactory "addition agent."

To explain the good and bad action of the organic "addition agents" mentioned above is no easy matter, as their chemical structure, except tannin, is not yet fully and definitely known. It may, however, be of value to cite their properties. Tannin  $C_{12}H_8(OH)_2(COOH)_2$  possesses characteristic acid properties and contains three hydroxyls per molecule. Gelatine, whose chemical structure is not yet fully known, is also essentially acid in character, as it possesses, when pure, an acid reaction and dissociates carbonates.

Peptone\* is of two kinds, which differ from each other in one molecule of  $H_2O$ . Their chemical compositions may be shown as follows:  $C_{27}H_{31}N_5O_9$  and  $C_{28}H_{33}N_5O_{10}$ . The former is called A-peptone and the latter B-peptone. Peptones are pronounced acids, which redden litmus paper and form salts with carbonates after having expelled the carbonic acid gas; adopting the simplest formula, peptones are monobasic acids, but such a simple formula has to be multiplied.

(4). The deposits of copper obtained from electrolytes containing the combined "addition agents" are all satisfactory, particularly when the combination of gelatine and sodium chloride is used. The striking effect of the inorganic substances, when present with the organic, is that it counteracts the bad effect of the latter. Of the two inorganic compounds (sodium chloride and hydrochloric acid) that were used for the combined "addition agents," sodium chloride is in every case better, more satisfactory and more effective in producing good copper.

This shows that the better effect is due to the presence of the sodium ion in the electrolyte. As evidence a particular case may be cited, that is, a case in which peptone and sodium chloride and peptone and hydrochloric acid were used as combined "addition agents." The copper deposits obtained in the former case were found better, both in physical character and purity.

In considering what has been said above, the question may now arise: What causes the organic compounds to behave so differently in the electrolytes when an addition of a small amount of either sodium chloride or hydrochloric acid is made? Does the presence of either of these two inorganic compounds cause the organic ones to undergo a chemical change? These questions cannot be answered without special investigations and were not within the scope of the present research.

With the results that have been obtained, and with the effects of various "addition agents" that have been tried, this may be said: The combined "addition agents" of gelatine and sodium chloride, when present in a small amount (say 0.01 to 0.02 per cent gelatine and 0.01 per cent Cl as NaCl), proves to be the most suitable and most satisfactory "addition agent" for copper sulphate electrolytes containing, especially, a high proportion of arsenic, as the deposited copper possesses the greatest ductility and the highest purity.

**Calcium and Molybdenum for Hard Copper Wire.**—A recent British patent (7657, April 20, 1911) of the Electrochemische Werke Ges. (Berlin) refers to a process in which up to 1 per cent of calcium or molybdenum or smaller percentages of each are added to electrolytic copper instead of aluminium and magnesium as is now usual to produce hard wires for overhead lines. Whereas a usual requirement for such wires is a conductivity of 95 per cent with a tensile strength of 40 kg to 46 kg per square millimeter, a wire with 0.35 per cent of calcium is stated to give on test 98 per cent conductivity and a tensile strength of 54 kg per square millimeter. Similarly, a wire with 0.05 per cent of molybdenum is stated to give 96.2 per cent conductivity and a tensile strength of 52.9 kg per square millimeter. By adding 0.35 per cent of both calcium and molybdenum to pure copper a conductivity of 98 per cent and a tensile strength of 52 kg per square millimeter are said to be obtained.—London *Elec. Eng'ing*, April 27.

\**Trans. Amer. Electrochem. Soc.*, 1909, Vol. 15, p. 473.

\*\**Chemistry of Proteids*, Mann, p. 188.



## Notes on Chemistry and Metallurgy in Great Britain.

(From Our London Correspondent.)

### The Causes of Corrosion.

The corrosion research committee of the Institute of Metals is making arrangements for conducting an extensive series of investigations into the causes of corrosion in brass condenser tubes, for which purpose a condenser is being made with 48 tubes, 24 of which are of commercially pure brass, while the rest will severally contain one of the following metals: Lead, tin, aluminium, manganese, or any other substance the effects of which the committee may desire to ascertain. The water speeds will be varied in numerical ratios, 2 being the average speed generally employed. The experiments will be continued for several months and will be carried out under the personal supervision of Mr. G. D. Bengough at the University of Liverpool.

### An Unusual Cause of Rusting in a Shipyard.

At last month's meeting of the Newcastle Section of the Society of Chemical Industry, Mr. F. C. Garrett said it was generally found that during the building of a ship rusting proceeded only to such extent that when ready for painting the plates could be easily cleaned of scale, but a case had recently occurred where rusting was so extensive that the extra scraping was very expensive and caused some anxiety on the part of the builders lest it should recur after completion.

The ship in question was near the eastern boundary of the yard; and another ship, about a quarter of a mile further to the west, built of the same make of plates, was but slightly more rusty than usual, showing that the fault was not with the plates. The aqueous extract from the rust of the western ship gave 0.342 per cent of a brown substance which slowly absorbed moisture from the air, while the rust from the eastern ship yielded 0.804 per cent of a nearly white and very deliquescent solid.

Analyses of these substances showed for the eastern ship 10.43 per cent calcium, 7.72 magnesium, with 41.6 chlorine, and for the western ship 5.68 per cent calcium, 4.24 magnesium, with 21.78 chlorine. The chlorine calculated for the Ca and Mg amounted respectively to 41.38 and 20.7. The rust from the western ship, therefore, contained 0.1047 per cent of mixed chloride of calcium and magnesium, and that from the eastern ship, 0.478 per cent of the mixed chlorides; and as the rust on the latter was at least twice as much as on the other, it must have contained about 10 times the quantity of chlorides per square foot.

It was found that excavation had been carried on just over the eastern boundary of the yard, involving disturbance of some alkali waste. A sample of this waste could not be obtained, but the local limestones commonly contain much magnesium, and the air was found to contain a chloride—probably hydrogen chloride.

### A Ferro-Concrete Pier.

At a meeting of the Concrete Institute Mr. C. P. Taylor mentioned some novel features in the design and construction of the ferro-concrete pier at the Swanscombe works of the Associated Portland Cement Manufacturers.

The foundations consisted of 32 columns, which, except at the corner, were constructed in pairs on 25-ft. centers, the longitudinal pitch being 28 ft. Each pair of columns was connected just above low-water level by a horizontal brace and at the top by a cross-beam. Between the last three pairs of columns at the outer end of the pier there was also a reinforced diagonal strut. The top cross-beams were extended at each end to form a cantilever and the ends of the nine rows of longitudinal beams were built into them.

The nature of the river bed made it desirable to use a construction involving a *minimum* of long piles. The other chief idea underlying the designs adopted was the desirability of carrying the full diameter of the columns right down to the

bed of the river without necessitating the deposition of concrete through water. The author considered that the practice of depositing concrete down a shoot inside a shell through a considerable depth of water produced a structure of very questionable strength. Mr. R. G. Clark, therefore, worked out a system of constructing the columns in which the concrete carrying the weight of the structure was in the form of blocks molded on shore and matured before being placed in position. The blocks were laid one on the other surrounding a central pile, and keyed together, and also by rails passing through vertical holes around the pile. The only concrete which had to be deposited under water was that used for filling around the pile and the rails. The central pile alone was not sufficient to carry the total weight borne by each column (about 150 tons) and the base of the column rested on piles driven round the center one and cut off near the ground level.

When the columns were completed the longitudinal beams, all of identical design, were lifted into place by the crane and were temporarily supported on rolled steel joists reaching across the pier on each side of the tops of the column. This plan saved much heavy shuttering which would have been necessary to mold the beams in place and also falsework to support the shuttering. After placing the nine longitudinal beams, the crane and other plant were moved forward for building the next pair of columns, and the molding of the main cross-beam and stiffener was put in hand.

Novelty was not claimed for making the longitudinal beams separately and lifting them into place, although the author did not know of any case where such large beams had been dealt with in this way. The author concluded with a detailed discussion of the especial stresses involved.

### Concrete Water-Pipes.

The laying of the reinforced concrete water pipes on the Bonna system for the conveyance of the new water supply to Clydebank has been completed, and the pipes are now taking the water from Burncrooks to the filters at Cochno, distant about 10 miles. There is good authority for stating that the jointing problem has been solved and that no trace of leakage can now be found. The work was begun by contractors, but the corporation had to complete it themselves. The entire cost, including repairs while the work was suspended, is said to be less than that of iron pipes.

### Tungsten and Tool Steel.

In an article in the *Times* of April 19 the statement was made that "the first commercial application of tungsten in steel manufacture was by the Bethlehem Steel Company of U. S. A. at the Paris Exhibition in 1900." Mr. Julius L. F. Vogel, a week later, wrote to point out that, although the Taylor-White steel then demonstrated was perhaps the first tool steel of which tungsten was publicly stated to be an important ingredient, Messrs. Osborne, of Sheffield, had very many years earlier incorporated a certain amount of tungsten in what was known as "Mushet" steel, and long before the Paris Exhibition this was employed in a small way in engineering works where specially hard cutting edges were required. Machines in use some 10 years ago were quite incapable of employing such steels to advantage, if at all, as they had not sufficient strength to do the work.

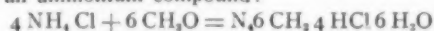
The growth of the high-speed tool was, therefore, dependent upon their replacement by others of special strength and design to work with the heavy cuts and high speeds of which the improved tools were capable. At the present day suitable machines for using high-speed tools are the rule and not the exception; hence the consumption of tungsten has continued to grow steadily.

In view of the fact that the supply of tungsten is comparatively limited it is fairly obvious that competition for the control of tungsten between three rival manufacturing countries such as Great Britain, United States and Germany must inevitably follow. The importance of Great Britain being self-supporting is apparent.



### Rapid Method for Estimation of Sulphur in Coal-Gas, or of Ammonium Sulphate.

At the meeting of the Newcastle Section of the Society of Chemical Industry Mr. H. BLAIR read a paper on this subject. Ammonia can be determined rapidly and accurately by utilizing the reaction of Malfatti, viz., the formation of hexamethylene-tetramine and liberation of acid on adding formaldehyde to solution of an ammonium compound:



The liberated acid is titrated by standard alkali with phenolphthalein. For the determination of sulphur in coal-gas the liquor obtained in the "referee's test" is made up to 500 c.c., and 50 c.c. are boiled for a few minutes to expel carbon dioxide; to the hot solution 10 c.c. of formaldehyde solution (about 30 per cent) are added, and the titration is at once made with decinormal potash, 1 c.c. of which is equivalent to 0.0247 grain of sulphur. The potash solution is best standardized by means of a standard solution of ammonium sulphate containing a little ammonium carbonate.

The results come out consistently and a little higher than those obtained by the barium sulphate method, but the discrepancy is not important—figures obtained being 5.064 against 4.53; 10.89 against 10.19; 33.97 against 32.81; and 25.04 against 24.98. The method can be employed for the estimation of sulphur in a smaller volume of gas, such as 1 cu. ft. or 2 cu. ft. The required volume is burned under an adapter and the products of combustion are aspirated through solution of ammonium carbonate which is treated with formaldehyde as above.

For the estimation of ammonium sulphate the salt is dissolved in water and its acidity neutralized with caustic potash; an aliquot part is boiled, formaldehyde is added, and the whole is again boiled for a few seconds, phenolphthalein is added and the titration is made with decinormal potash: 1 c.c. = 0.0049  $\text{H}_2\text{SO}_4$ ; 0.0017  $\text{NH}_3$ ; 0.0066  $\text{Am}_2\text{SO}_4$ . The results agree closely with those obtained by the barium sulphate method.

### Volumetric Determination of Tungsten.

E. Knecht and E. Hibbert reduce the tungstic acid or its salts with granulated zinc in a strong hydrochloric acid solution until a brown solution of tetrachloride is produced. Potassium thiocyanate is added as an indicator, and the tetrachloride is reoxidized by standard solution of iron alum in an atmosphere of carbon dioxide. During titration the brown color changes to blue, which persists until the end-point and may serve as an indicator instead of the thiocyanate. The presence of ferrous iron does not affect the titration. In the case of ferro-tungsten the authors recommend decomposition with potassium persulphate—fusing 0.1 gram of the alloy with 4 grams of persulphate in a porcelain crucible, taking up with water, making alkaline with sodium hydroxide and filtering. The tungsten is determined in the filtrate, and the iron on the filter may be dissolved and estimated.

### Recovery of Zinc from Ores and Waste Material.

Mr. A. Gutensohn (Eng. Pat. 9818, 1910) mixes the ore, or other material containing zinc, in a powdered state—and after roasting if necessary—with carbon and a collecting material consisting of 20 parts lime, free as possible from silica, with one part each of iron borate and manganese borate. The quantity of carbon employed is the same as the estimated weight of the zinc in the ore, etc., and the collecting material used is one-fifth of that weight. The mixture is heated in a retort at such a temperature that the zinc is the only ingredient melted. For the production of zinc oxide the condenser pipes are fitted with air inlets.

### Uranium.

W. P. Jorriksen and A. P. H. Trevelli have found that on exposing commercial metallic uranium to the action of cathode rays nitrogen was given off in considerable quantity. Further research demonstrated the presence of 13 per cent of uranium nitride,  $\text{U}_3\text{N}_4$ , and 1.25 per cent of carbon.

### Hydraulic Bronze Castings.

Sergius Kern states that castings suitable for high-pressure hydraulic and steam apparatus can be made by melting 78 parts of best copper with 10 of good brass in a covered crucible holding at least 2 cwt. and then adding successively 12 parts of tin, 1.4 of zinc and 0.12 of cupro-silicon containing 10 per cent of silicon. As soon as diffusion of the components is complete the alloy should be poured into the molds.

### Market Prices.

April, 1911.

Copper has remained fairly steady, between the limits of £53.12.0 and £54.15.0 per ton. It opened at £54.11.3, was depressed from 10th to 20th to £53.12.0 or about, then rallied slightly, and is now quoted at £54.

Tin has, over the whole month, risen. It opened at £188.15.0, rose to £192 by the 5th, fell smartly to former price, recovered on 7th, and has since kept fairly steadily on the upgrade though always a nervous market. Closes, £193.15.0.

Lead steady at £13.2.6 to £13.5.0 throughout the month. Opened at £13.5.0, closes at £13.3.9.

Iron Hematite opened at 65/-, but continued to fall, reaching 62/6 on the 20th; since recovering to 63/3.

Scotch Pig also inclined to be lower. Opened at 53/7½, and dropped to 52/9 by the 5th, recovering 3d. by the 12th, since steady at 52/7½.

Cleveland Warrants opened at 47/7½, and had dropped to 46/4½ by the 19th, since recovering to 46/6½.

	£	s.	d.
Alum, lump, loose, per ton.....	5	12	6
Antimony, black sulphite powder, per ton.....	22	0	0
Borax, British Refined Crystal, per ton.....	16	0	0
Copper ore, 10 to 25 per cent, per unit.....9/- to	0	9	6
Copper sulphate, per ton.....	19	15	0
Carbolic acid, liquid, 97/99 per cent, per gal.....	0	1	5
Creosote, ordinary good liquid, per gal.....	0	0	2
Camphor, 1-oz. tablets.....	1	9	
Caustic soda, ash, 48 per cent, ordinary, per ton..	5	10	0
Litharge, flake, per ton.....	15	10	0
Mica, small slab, original cases, per lb.....6d. to	2	0	
Naphtha solvent, 90 per cent at 160° C., per gal...			9
Petroleum, Russian spot.....			47½
Sal ammoniac, lump, firsts, delivered U.K., per ton	42	0	0
Sulphate of ammonia, f.o.b. Liverpool, per ton..	13	15	0
Sulphur, recovered, per ton.....	5	0	0
Shellac, Standard T. N., orange spots, per cwt..	4	4	0
Tin ore, 70 per cent, per ton.....£123 to 125	0	0	
Hydrochloric acid, per cwt.....	0	5	0

Platinum, per ounce, has been steady at £86.6 throughout the month.

India Rubber, Para fine, has been steadier and lower. Opening at 5/9½ it rose to 6/- by the 5th, and thence dropped to 5/5, and ultimately 5/0½. Now quoted at 5/3½.

On the month the following differences are noticed:

	Lower.	Amount.		
		£	s.	d.
Copper .....		0	15	0
Lead .....		1	3	
Hæmatite .....		1	0	
Scotch pig .....		1	0	
Cleveland warrants .....		1	1	
India rubber, Para fine.....		0	6	
Copper sulphate .....		2	6	
Camphor .....		1		
Sulphate of Ammonia .....		12	6	
	Higher.	Amount.		
		£	s.	d.
Tin .....		8	2	6
Mica .....		1	0	
Shellac .....		11	0	
Tin ore .....		11	0	0

## Synopsis of Metallurgical and Chemical Literature.

## Gold and Silver.

**Amalgamation of Gold in Banket Ore.**—In the March, 1911, issue of the *Journal of the Chem. Met. & Mining Soc. of South Africa*, W. R. DOWLING presents a review of the methods of amalgamation used on the Rand before and since the war. The improvement in methods of metallurgy on the Rand has made it possible to treat lower grades of ore, and the large scale of operations has made it necessary to simplify procedure.

In the early days of the Rand the main source of gold recovery was amalgamation, assisted by concentration and Chlorination. To obtain maximum recovery it was considered necessary to catch the gold as soon after its release as possible, and therefore inside amalgamation was practised. Outside were the usual apron plates with mercury wells between. Mercury also was fed to the mortar. It appears that the percentage recovery in the early days on an oxidized and rich ore by the various methods then in use was not much less than is obtained by the present fine crushing from low-grade pyritic ore by the ordinary straight mill plate and shaking tube mill plates as used to-day.

A most important change was brought about in 1890 by the introduction of the cyanide process. It was at first applied only to coarse leachable ore, and as it was the practice to make as little slime as possible it follows that amalgamation recovery dropped on account of the coarse crushing. When the slime methods came into vogue in 1894 the fine grinding was again possible and the amalgamation recovery assumed its normal condition. The use of lime as a settling factor also was of benefit to amalgamation as it caused the slime to agglomerate

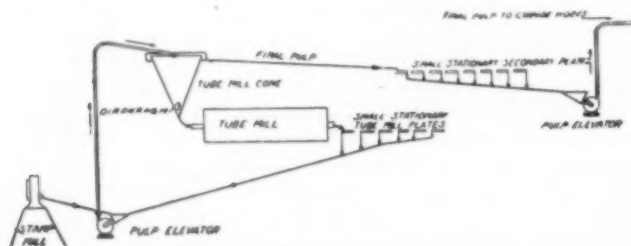


FIG. 1.—RANDFONTEIN CENTRAL ARRANGEMENT. SIX SMALL STATIONARY TUBE MILL PLATES AND EIGHT SMALL STATIONARY SECONDARY PLATES FOR FINAL PULP.

in particles which could come in contact with the plates better than fine disseminated slime. Finally the introduction of tube mills raised the recovery by amalgamation to 65 to 70 per cent of the contents of the ore, of which some 10 to 15 per cent was from the tube mill plates.

Coming nearer to the present time we find that the increased use of tube mills for regrinding permits of coarser crushing at the stamps and consequently the necessity of recovering the plates from the stamps on account of the scouring of the coarse pulp. The author finds that this change gives rise to five possibilities of arrangement of the tubes and plates, and these are illustrated in diagrams, Figs. 1 to 5.

- (1) Amalgamation of the tube mill pulp by one set of plates and the overflow final pulp by another set.
- (2) Amalgamation of the tube mill pulp only.
- (3) Amalgamation of the mixed pulp after regrinding of the coarse portion of tube mills, as in recently erected plants.
- (4) Common arrangement, and (5) author's proposal.

It will be noted that plans 1 and 3 involve two elevations, while plan 2 involves only one. In this respect the latter is preferable. Plan 4 also involves but one elevation of pulp, but it also has stamp mill plates, which, the author points out, are better removed, as they make immediately available the gold which otherwise is tied up in them, and permits placing all the plates in a separate house.

The number of plates required after tube mills, and the question as to whether they should shake or be stationary, is referred to by the author. We refer our readers to our May issue, p. 279, for data on this subject.

To ensure successful and economical work the ratio of water to solid should be reduced to the minimum, as not only does this decrease the velocity of the stream over the plate, but the cost for re-elevation is also less. The fall given to stationary plates is 18 per cent, and with this fall it is found that the minimum percentage of water in the pulp is 55 per cent. The

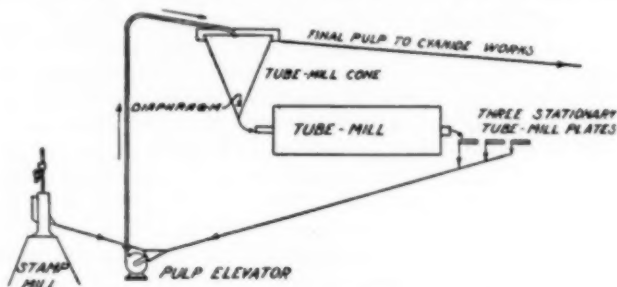


FIG. 2.—SIMMER AND JACK ARRANGEMENT. THREE STATIONARY PLATES IN TUBE MILL CIRCUIT.

point to be reached in water ratio and fall is just short of the banking of sand on the plate.

The author favors the removal of plates from the stamp mill to a separate house, as such an arrangement will result in increased running time by not having to hang up the stamps for cleaning the plates and more attention can be given the crushing apparatus. Better amalgamation also should result by the closer attention made possible, and there would be less opportunity for pilfering gold by employees who necessarily have to work about the stamp mill, but who could be kept from the plate house. Where the plates are removed from the stamp mill the water ratio may be considerably reduced.

The author is of the opinion that the ratio of amalgamation plate surface to stamp unit is entirely too large. At the Randfontein Central the area amounts to 9.6 sq. ft. per stamp unit, but it is now proposed to reduce this to one-half that area. In the Simmer and Jack rearrangement the plate area is about 2 sq. ft. per stamp unit. Advantages resulting from this reduced plate area are reduced cost of installation and operation and reduced cost of mercury consumption. Less gold also will be required to set the plates, and as a well set plate will have about 1 oz. of gold per square foot it will be seen that the sum thus tied up can amount to considerable in a large mill.

## Dry Washing for Placer Gold.—The Altar district, So-

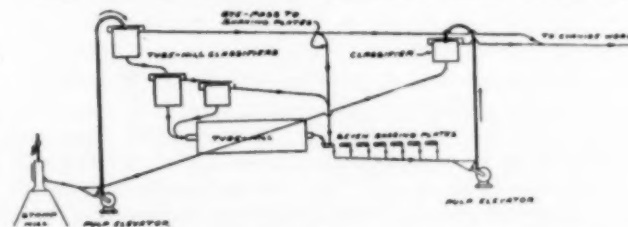


FIG. 3.—RECENT ARRANGEMENT. SEVEN PLATES AMALGAMATING TOTAL MIXED PULP.

nora, Mexico, is for the most part a desert, with but little rainfall and few running streams. On account of this dry condition it is necessary to "dry-wash" the cement gravels containing gold. The operation is described by J. V. RICHARDS, of Spokane, Wash., in the April *Bulletin* of the American Institute of Mining Engineers.

It is said that as long as a century ago the Yaqui Indians discovered rich cement gravel, known as *argo masa*, at Las Palomas, and that there has been a more or less steady pro-

duction of gold from the property ever since. The *argo masa* is a fairly coarse gravel, the pebbles being held firmly together with a lime cement. Gold is scattered through this cement in particles ranging from fine specks to pieces several grams in weight, and occasional large nuggets are encountered. The contents vary so widely that it is difficult to estimate the value of the gravel, but returns of \$10 to \$50 per cubic yard are common, and it is doubtful if the Indians considered anything less than \$4 to \$5 per yard as pay dirt. The *argo masa* occurs in channels varying in thickness from a few inches to several

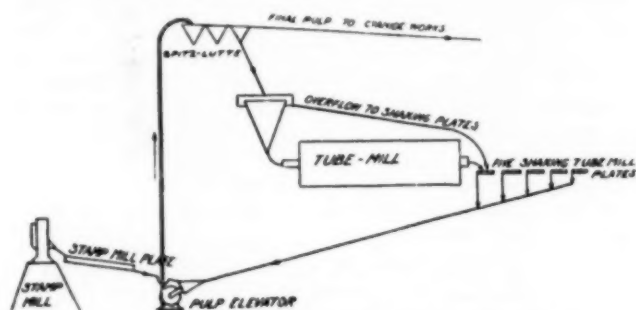


FIG. 4.—COMMON ARRANGEMENT. ONE PLATE FOR FIVE STAMPS AND FIVE SHAKING TUBE MILL PLATES FOR ONE TUBE MILL.

feet, and in width up to 300 ft. These channels are probably ancient stream beds and are overlaid with more recent gravel garying from 30 to 50 ft. in thickness. The overburden contains values as high as \$1.50 per yard.

The old Yaqui method of working the ground was to sink shafts and gouge out the cement gravel as far as possible from the bottom of the shaft. Owing to lack of timber for supports, the ground frequently caved, and but little work could be done from any one shaft. After the cement is hoisted, it is pounded between boulders, the coarse gravel removed and the fine cement panned in *bateas*. While this method is laborious, the Indians and Mexicans are expert in the operation, and but little coarse gold is lost. More material can be handled by the dry washer, but the preliminary pulverizing is the same as for the *batea*.

The dry washer is an air blast machine working on the difference in specific gravity of metal and gangue. It is a small table with a cloth top and a bellows below. The table is about 4 ft. long by 2 ft. wide, and has a hopper at one end through which the gravel is fed. The top of the table contains a fine wire netting like ordinary fly screen. On this is placed one and sometimes two layers of burlap, and over this a layer of thin cotton cloth; old flour sacks are sometimes used. Four ½-in. riffles are fastened at equal intervals across the surface, and detachable sides are used to keep the gravel from spilling over. The machine is usually set on the edge of a dump at an angle of 20 deg. from the horizontal, but is carefully leveled in cross-section.

A hand crank belted to a small drive wheel operates the bellows, which has the ordinary clap valves. Intermittent puffs of air come through the cloth at the rate of 150 per minute and cause the sand and gravel to jump the riffles and travel off the table. Most of the gold and black sand is caught behind the first two riffles. The capacity of such a machine is from 2 to 2½ cu. yd. per hour.

After several yards of gravel have been run the machine is stopped and the material behind the riffles brushed into a gold pan. It is then fed back to the machine and nearly all the free gold is caught behind the first riffle. The resulting gold, sand and black sand are then tossed in a *batea* and the gold recovered clean.

The material must be absolutely dry for this operation, only a small amount of dampness tending to clog the cloth and disturb operations. Hand pulverizing has to some extent been displaced by the Quenorr disintegrator, which is a cylinder 7 ft.

long and 4 ft. in diameter, made up of 1½-in. steel strips set ⅛ in. apart. In the center is a shaft to which are attached chains having tough, manganese-steel lugs at the free ends. The cylinder revolves at the rate of 40 r.p.m. in one direction, and the center shaft revolves in the opposite direction at four or five times this speed. The cement gravel fed in at one end is thoroughly disintegrated by the lugs and falls through the slits, the coarse pebbles being rejected at the end.

At first sight the dry washer appears to be a crude machine, but a test made by the author showed that gravel worth 70 cents per yard gave tailings worth only 10 cents, or a saving of over 85 per cent, and he believes that the general recovery of fairly coarse gold is in excess of 80 per cent.

### Zinc.

**Modern Zinc Problems.**—In his presidential address delivered before the Institution of Mining and Metallurgy, London, Mr. H. LIVINGSTON SULMAN gave an interesting and instructive review of zinc metallurgy and the problems yet to be solved.

In no department of metallurgy has development been more rapid than in the treatment of "complex ores." Just as the terms "free milling" and "refractory" applied to gold ores have lost their older significance, so a few years hence the word "complex" will cease to be used as a prefix to zinc-lead-silver-copper ores, and as a reproach to reduction practice. Many millions of tons of such material have been found, and in some instances partly developed, whose contained metals at current prices render them equivalent in value to two-ounce gold ore. The "complexity" usually is due to blende, usually more or less ferruginous, in intimate physical association with galena and other minerals. Most lead mines are also zinc producers, and every zinc deposit carries lead. When it is possible to dress these ores so as to produce a clean galena concentrate and a zinc portion containing 40 to 45 per cent metal, the ores are not "complex," but the finer parts and slime are still complex in the sense that their separation still awaits solution. The Broken Hill deposits with their intercrystallized galena and ferruginous blende, rhodonite and garnet gangue, which formerly prevented the separation of zinc, are of decreasing complexity since the advent of flotation methods. The slime reserves, however, still present difficulties of treatment.

A more truly complex problem is that which occurs in Tasmania, where the presence of copper adds to the problem. The difficulty in this instance is that the ore contains but little gangue, and concentration by any method is of little or no effect. Successful reduction must be sought by direct smelting, or the removal of the zinc by leaching processes. Complex carbonates also are known, as those of the Rhodesia Broken

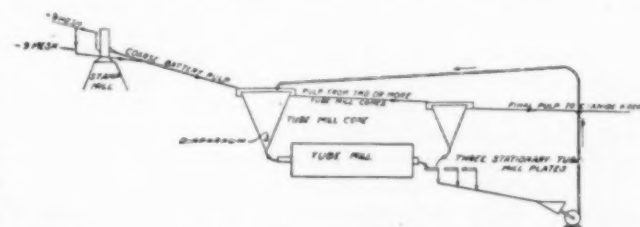


FIG. 5.—PROPOSED ARRANGEMENT. THREE STATIONARY TUBE MILL PLATES.

Hill region, where zinc and lead occur as mixed carbonates. Again, there are those ores in which the presence of fluor spar prevents the usual retort reduction methods for zinc, and which probably will have to be reduced in the electric furnace.

The methods of attacking such ores may be divided into proximate or mechanical, and ultimate or leaching and smelting processes. Proximate methods are limited by the conditions encountered in crushing heterogeneous materials to free the component parts, and usually are inefficient by reason of having to produce several grades of mineral, or a low grade



if all be mixed. Among the proximate methods which have come into prominence is the flotation group.

The simplest type of flotation methods is represented in the DeBavay process used at Broken Hill, and in the Macquisten tube, reference to which was made in our issue for May, 1911, p. 236. In these the surface tension of water is used to float off the sulphide particles, which are not easily wetted, whereas the more readily wetted gangue particles sink when a mixture of mineral and gangue is presented to a surface of flowing water. A second variety is the Potter process, in which submerged sulphide particles are caused to rise to the surface of a hot acidified pulp by the fixation of gas bubbles; the gas in this instance being carbon dioxide generated by the acid on siderite. The third variation includes the well known oil processes of Elmore and Minerals Separation, Ltd., which secure the flotation of submerged minerals by means of bubbles of air, such mineral particles having previously received a slight film covering of oil for the purpose of effecting the air or gas attachment. To Elmore undoubtedly belongs the honor of first bringing oil-mineral processes into the realm of commercial practicability. To Froment and especially to Cattermole we are indebted for the next important development. The latter first demonstrates the efficiency of a very small quantity of oil in place of the large bulk hitherto employed.

The physical reactions which underlie all such methods have been insufficiently explored, and in many respects are still obscure; the striking practical results so far achieved have been reached quite empirically. The author mentions a new fact in relation to the measurements of the "contact angles" which exist between the surfaces of aqueous liquids and those of certain sulphides, silicates and other solids. In investigating previously accepted figures for these, he finds discrepancies in the readings, which on further investigation prove to be due to the existence of a variable range for the contact angle between various liquids and solids, though of constant magnitude of variation for each. This range of angular variation has been called by C. G. Lamb, "the angle of hysteresis," and its existence and magnitude in regard to many substances have been independently confirmed and quantified by A. Howard Higgins. It is not a fact of merely academic interest, as it appears to be intimately connected with the ability of a given solid to condense upon itself a gas film; and when submerged in a liquid to determine the attachment of a gas when generated, or on the point of generation, from a solution. It follows that angular hysteresis reaches its highest values for minerals which are most susceptible of flotation, and *vice versa*. Hundreds of observations have been made which place this relationship beyond doubt. Besides roughly quantifying the gas condensing power due to the surface energy of solids, it brings us somewhat closer to an explanation of the efficiency of acidification. Thus, whereas the angular hysteresis of silica in plain water may exceed 30 deg., thus indicating that substance to have a definite power to occlude gas and to float, it drops from 4 deg. to 0 deg. in water acidified with sulphuric acid. Galena, on the other hand, retains its full measure of angular variation or is but slightly affected.

While certain difficulties remain to be solved, especially in regard to blende and galena slime, the Broken Hill problem may be regarded as solved by the flotation processes. It must be remembered however, that the methods referred to work effectively only on particles of sensible size.

The slime problem has been studied by Horwood, who operates by superficially attacking one particle while leaving the other unaltered, and thereafter submits the product to oil flotation. He usually employs heat to effect this differentiation, a low temperature oxidizing the surface of the galena while the blende remains unaltered. The Minerals Separation process is preferred for this work as it deals better with slime.

Magnetic separators employing fields of high intensity still have a wide range of usefulness, although on dry ore have given trouble on account of dust. Wet types have been ex-

tensively experimented with, and lately Mr. Ullrich has introduced a multipolar ring machine which overcomes the difficulty of removing small particles from a liquid. Several of these machines are already working, and their possibilities regarding slime mineral are receiving close attention.

Electrostatic methods are revived in the Huff machine. To L. I. Blake is due the credit for first introducing a commercial separator on the electrostatic principle. He was followed by Sutton and Steele, in whose machine the electrode was charged inductively by a brush discharge, and was furnished with an ingenious interrupter whereby any desired degree of saturation of the separating roller could be obtained to suit the varying electrical capacities of the minerals to be separated. An electrostatic generator also was employed in this machine. The main advance in the Huff machine is the substitution of a dynamo current of suitable intensity for the electrostatic energy of a Wimhurst machine. The limiting factor of electrostatic separators is their inability to handle fine powders, and their liability to dust troubles unless the dust first be removed.

In the mechanical treatment of slime we reach the limit of proximate methods of handling zinc ores, and must take up ultimate methods such as smelting and hydrometallurgical processes. Dealing with smelting, the author mentions H. Pape's process in Germany. Low grade zinc-lead ores are smelted with sufficient silicious ore to slag off the zinc and reduce the lead. The slag of zinc silicate is then crushed and briquetted with sufficient carbon and a binding agent, and charged into a blowing furnace, fitted with a special grate on which the briquets are charged to a depth of three or four feet. Upon ignition, the zinc is first reduced and then blown off as oxide, while the depleted slag flows through the grate. The separation goes on almost to completeness, and the zinc oxide is collected in chambers and bags.

Referring to leaching methods, the bisulphite process is described as follows: Roasted ore is subjected to the action of water and dissolved sulphur dioxide gas, the latter being derived from the roasting operation. The zinc is dissolved as bisulphite and separated from the residues which contain lead, silver and other metals. From the solution the zinc is thrown down as insoluble monosulphite by removing one of the equivalents of sulphurous acid gas. The precipitate is then calcined, resulting in the production of a dense zinc oxide suitable for reduction to spelter. Sulphate of zinc accumulates gradually in the liquors until they are strong enough for recovery of the salt by crystallization.

A means for the reduction of zinc sulphate is provided by electrolysis, the deposited zinc being stripped from the cathode and remelted to spelter, while the acid regenerated at the anode is used for the leaching of fresh oxidized zinc from roasted ore. In practice it is found that about 5,500 electrical horsepower, as a mean figure, is required to produce a ton of deposited zinc, or roughly two-thirds of an electrical horsepower-year. Wherefore, localities favored with cheap water power will hold an advantage in the production of electrolytic zinc, for the process could hardly supersede the present distillation processes if located at existing reduction centers.

The author concludes with a review of electric processes for zinc, but as these have been given full attention in our issue for May, 1911 (see also our Vol. VIII., pages 49, 99, 289, 317, 688, 689), they will not be mentioned here.

#### Physical Chemistry and Electrochemistry.

**Specific Heats of the Elements.**—In a recent number of the *Zeit. f. Elektrochemie* J. KOENIGSBERGER publishes a compilation of values obtained by himself, Nernst, Richards, Dewar and others for the atomic specific heats of the elements. It is shown that there is a distinct difference between the specific heat of a good conductor and that of an insulator. The values for metals cooled to very low temperatures are very near those

for insulators at high temperatures. The value  $c_p$  for carbon, in the shape of diamond, is almost zero at  $-180^\circ$  and at  $1500^\circ$  it has increased to  $c_p = 6$ .

**Colloids.**—In the *Zeit. f. Elektrochemie*, April 15, A. LOTTER-MOSER gives a very careful review of all important papers and patents on colloids that appeared in 1908. Among the headings under which the subject matter is treated are: Electro-osmosis, the theory of dyeing, flocculation, production of colloidal metals and metalloids on a commercial scale, lubricants and albumen.

**Thermodynamics of Galvanic Cells.**—In the same number R. LUTHER publishes a note on *Lead-Mercury Cells*. He finds that according to electromotive force determinations the heat of reaction of  $Pb + 2HgCl = PbCl_2 + 2Hg$  is equal to 21,900 calories; from thermodynamical data of Nernst and Thomson the value 20,100 is derived. This leaves a difference of 1800 calories between the two values. No satisfactory explanation of this discrepancy has as yet been found.

**Sharpening of Tools by Electrolytic Etching.**—In *Dingler's Polytechn. Journal*, Vol. 35, 1910, page 747 (abstracted in *Elek. Zeit.*, Jan. 26, page 93), E. SCHNECKENBERG discusses the use of the electric current for the sharpening of tools by electrolytic action. Barthel formerly used a mixture of three parts of 66 per cent sulphuric acid and 6 parts of 40 per cent hydrochloric acid. The file or cutter to be sharpened was first cleaned from fat and dirt and then suspended together with a carbon electrode into the above solution. This represented a short-circuited cell and the file or cutter was automatically sharpened. Gratwohl has recently modified the method by employing an inert load electrode instead of the carbon electrode and a primary battery or storage battery giving 1 volt or 2 volts as an external source of current. He uses an electrolyte of a sulphuric acid solution of specific gravity 1.18.

## Recent Metallurgical and Chemical Patents.

### Iron and Steel.

**Briquets of fine iron ore** may be made according to the formula of GEORGE K. HOLLISTER, JR., of New York City. He proceeds preferably as follows: Say 2,000 pounds of fine iron ore are mixed with 15 pounds of clay in a dry and pulverized state. To this is added, during a mixing operation,  $3\frac{1}{2}$  gallons of molasses slightly acidified with two ounces of hydrochloric acid, and three gallons of water containing two pounds of sal soda and one pound of powdered alum. When the ingredients are thoroughly mixed the mass is placed in a pug mill and heated evenly to a temperature of about  $350^\circ$  F. until the material has lost its wet appearance and feels dry to the touch. It is then passed through a briquetting machine. By this procedure the inventor claims to obtain a hard, practically unbreakable briquet, due to the bond formed by the salts and clay, and to the carbonization of the molasses. It is claimed that the briquets can be used in the smelting furnace immediately after leaving the machine. (990,049, April 18, 1911.)

### Copper.

**Improving Conductivity and Tensile Strength.**—The improvement of copper and its alloys for electrical work by increasing the tensile strength and conductivity is the basis of a patent granted to RUDOLF FRANKE, of Eisleben, Germany. The process has been assigned to the Elektrochemische Werke (G. M. B. H.), of Berlin, Germany.

Three classes of wire are used in telegraphic and telephonic work in Germany, viz., chemically pure copper wires, bronze wires and double bronze wires. The bronze and double bronze wires are treated with a composition consisting of 64 per cent aluminium and 36 per cent magnesium, together with a little tin. The inventor has experimented to see whether the composition could not be replaced by calcium or by molybdenum. He produced both soft and hard-drawn wires as follows: 1. Wires without any addition. 2. Wires with the addition of calcium

in the form of calcium-copper containing 12.2 per cent calcium. 3. Wires with the addition of molybdenum in the form of metallic powder containing 97.1 per cent molybdenum and 3 to 4 per cent oxide, 1.4 per cent insoluble matter, 0.65 per cent iron and aluminium as carbide. 4. Wires with the addition of aluminium and calcium in the proportion of 42.3 per cent calcium and 55.85 per cent aluminium. 5. Wires with the addition of molybdenum and calcium, the latter in the form of calcium-copper. 6. Wires with the addition of aluminium-molybdenum-calcium, the calcium in the form of aluminium-calcium and the molybdenum as metallic powder.

The results of the tests showed that the addition of calcium as calcium-copper was far superior to the magnesium-aluminium composition; that molybdenum similarly gives better results than the composition referred to and about equal to those of calcium; that the addition of aluminium-calcium gives poor results; that calcium-molybdenum additions give the good results shown by the addition of either metal; and finally, the aluminium-molybdenum-calcium addition gives poor results and should not be used on account of the presence of the aluminium.

The tests establish to the satisfaction of the inventor that (1) calcium and molybdenum addition can be advantageously substituted for the aluminium-magnesium composition for hard-drawn bronze wires, and that (2) with an addition of at the most 0.35 per cent of calcium or molybdenum or both, hard-drawn wires can be produced with a tensile strength of 50 to 52 kg. per sq. mm., and a conductivity of 95 per cent. The patent specifications give the engineering results on many tests which are instructive and bear out the inventor's claims. (990,040, April 18, 1911.)

### Aluminium.

**A new solder formula** recently has been patented by JOSEPH N. DAUDELIN, of St. Hyacinthe, Quebec, Canada. It comprises a mixture of silver, phosphorus, copper, lead, tin, aluminium and zinc. The main object of the invention is to produce a solder having great tensile strength; one which will run easily; which may be used for aluminium as well as other metals; one which has a very low coefficient of expansion; one which is homogeneous, will not easily corrode and will be tough without being brittle. The various ingredients are claimed to give these properties to the solder. The inventor prefers to mix the metals in the following proportions: 22 grains of silver, 42 grains of phosphorus, 238 grains of copper, 1338 grains of lead, 5,051 grains of tin, 50 grains of aluminium, 939 grains of zinc. (989,573, April 18, 1911.)

### Electric Furnaces.

**Pinch Effect for Electric Furnace.**—In his recent American Electrochemical Society paper (our May issue, page 277), Mr. CARL HERING, of Philadelphia, Pa., described in detail an electric furnace in which he makes use of the "pinch effect" for circulation of the charge. A patent has now been granted to him on this process. Since the principles were already described quite fully in our last issue, we give here only two of the 34 claims. The first claim reads as follows: "In an electric furnace, a hearth for containing a mass of molten material, columns or channels communicating with said hearth and adapted to be filled with molten material in communication with said molten mass to constitute the furnace resistor, and electrodes in end on communication with said columns or channels, the square of the current transmitted through said electrodes to the molten material in said columns or channels with relation to the cross-section of said columns or channels being great, whereby said mass of molten material is automatically stirred." The twelfth claim reads as follows: "In an electric furnace, the combination with a mass of molten material, of a molten mass in communication therewith serving as resistor, the ratio of the square of the current through said resistor to its cross-section being great, whereby circu-



lation of molten metal is produced, and an electrode in communication with said resistor having such dimensions that the  $C^2R$  heat developed in said electrode by the current traversing said resistor shall be equal to substantially twice the heat conduction loss through said electrode when no current is flowing." In the specification the laws of the pinch effect and of the heat losses through electrodes are given and rules are derived for calculating the dimensions of the essential parts of the furnace. Various modifications of the simplest arrangement, employing two vertical columns to communicate with the hearth, are described. By arranging the resistor columns not vertically but inclined to the vertical, less hydrostatic pressure is developed in the columns. With three columns the furnace is adapted to three-phase currents. A double furnace is described for the production of steel directly from ore; in one of the furnace chambers the iron ore is reduced, in the other chamber the refining of the steel is performed, both chambers being heated from the bottom, each by a set of resistor columns. Combinations of this resistance furnace with the use of arcs at the top are also described. (988,936, April 4, 1911.)

**Electrode Arrangement for the Reduction of Radiation Loss.**—Mr. E. C. SPEIDEN, of the International Acheson Graphite Co., of Niagara Falls, has patented an arrangement of the electrodes above the bath for the purpose of reducing the direct radiation of heat from the surface of the molten bath. The electrodes are disposed in overlapping series, whether in parallel planes or in angular relation to each other, but in such a way as to protect, shield, or shadow the upper portion of the furnace structure, including the roof, from the effect of heat radiated from the zone of maximum temperature. (992,281, May 16, 1911.)

**Combination Bessemer-Electric Steel Process.**—A new combination process for refining Bessemer metal in the electric furnace has been patented by Mr. JAMES H. GRAY and assigned to the Illinois Steel Co. By the ordinary acid Bessemer process silicon and carbon are removed from molten pig iron; the metal is then dephosphorized in a ladle by means of a slag of lime and iron oxide (previously prepared in a cupola furnace); the metal is finally treated in an electric furnace for the removal of sulphur and oxygen. (987,715, March 28, 1911.)

#### Electrolytic Copper Refining.

**Purification of Electrolyte.**—In copper refining the solution becomes gradually impure and it is necessary to remove large quantities of the same periodically. The common practice is to crystallize out the bulk of the copper as blue vitriol (sometimes with the previous step of neutralizing the free acid of the electrolyte by passing over shot copper), and then precipitate the remaining copper on scrap iron. The residue is generally discarded. Messrs. C. H. ALDRICH and J. K. BRYAN, of Perth Amboy, N. J., propose to subject this residue to further purification. They concentrate the impure electrolyte (18 to 25° Be.) to 45° Be. in a lead-lined tank, heated by means of lead coils and concentrate it further in a lead-lined iron pan to 50° Be. The anhydrous salts are allowed to crystallize out until the bulk of the copper is removed. Thus far the process is the one usually pursued. But now instead of precipitating the copper, nickel and iron salts in one pan, the inventors let the mother liquor pass through a number of heated iron pans arranged in cascade. The mother liquor is thereby concentrated to 60 or 70° Be. and the salts are fractionally precipitated in the cascade of pans. The precipitate in the first pans is relatively rich in copper, that in the intermediate pans contains copper and nickel in about equal quantities, and that in the last pans is rich in nickel.

The resulting solution is allowed to settle in a tank from which it is then pumped into refining tanks arranged in cascade. This solution contains not only traces of copper, iron, nickel and zinc, but contains a material amount of arsenic and antimony in solution. In the electrolytic tanks a temperature

of 170° to 180° F. is maintained, insoluble anodes are used and cathodes of lead, copper or iron. The electrolysis is continued until the bulk of the arsenic, together with traces of the copper and antimony, have been deposited on the cathodes. The arsenic deposit contains copper, antimony, etc., from which it can be easily separated and recovered by burning in a small furnace with suitable condensing flues. The residue is composed principally of copper oxide which is worked up in a blast furnace in the usual way. The purified liquor is allowed to settle and then returned to the copper refining tank. (991,685, May 9, 1911.)

#### Petroleum.

**Separation of Oil and Water.**—Four patents recently issued to Mr. FREDERICK G. COTTRELL and associates, of Berkeley, Cal., are interesting for their application of the electric current to the separation of water from oil.

Crude petroleum as it comes from the wells is frequently accompanied by more or less water mixed with the oil in drops of macroscopic and microscopic size. The larger drops might settle in a natural manner, but the small ones will not so separate from the oil. Centrifugal action is wholly satisfactory and distillation is expensive. The inventors have con-

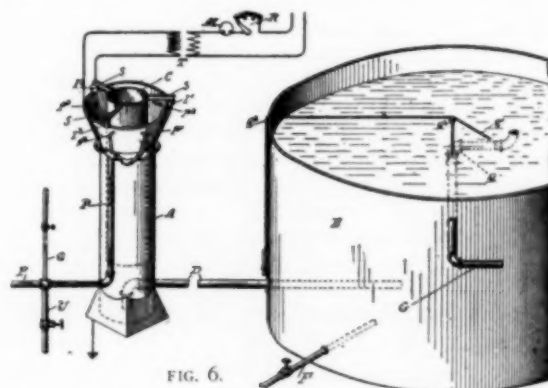


FIG. 6.

ceived the idea of applying a high-potential alternating current to the mixture, causing the water particles to coalesce into large enough drops to settle out of the oil.

Fig. 6 gives a complete view of a diagrammatic apparatus for carrying out the invention. The vessel A contains the oil undergoing treatment and is itself one of the electrodes, being connected with one of the high-potential terminals of the transformer T. The other terminal is connected to the electrode C which is represented as an inner concentric shell in the vessel A, although its exact form is a subject of another patent. The two electrodes are insulated as shown in the diagram at P, P.

The oil and water mixture to be treated is received through the pipe P, and may be heated by steam delivered from Q, and diluted if necessary by dry oil through U. The mixture enters the top of the vessel A through jets  $p^1, p^2, p^3, p^4$ , and flows down between the electrodes, and finally out through a pipe D, which is of sufficient diameter to insure a quiet flow, free from a churning effect which would again emulsify the separating oil and water. On entering the tank E, the water, which has been caused to gather into drops of large enough size to settle naturally, drops to the bottom. Dry oil can then be drawn off through G and water and sludge is drawn off through F.

Care must be taken to have the active portion of the electrodes deep in the mixture to avoid the possibility of the separated water forming surface layers and causing short-circuiting. The heating of the oil prior to its treatment improves its physical condition and in the present instance this can best be done by steam, since there is no objection to the introduction of water in the oil. Many other details of the operation and construction of the parts will be apparent on a study of the original patents. (987,114-5-6-7, March 21, 1911.)



### Automatic Gas Analysis for Boiler House and Chemical Works Control.

The following is a general description of the automatic gas analyzers made by the Precision Instrument Company, of Detroit, Mich., under license from Alexander Wright & Company, Ltd., engineers, of Westminster, England, and their two English directors, Messrs. John F. Simmance, M. I. M. E., and Jacques Abady, A. S. M. E.

These recording analyzers may be divided into two classes: Those for non-corrosive and those for corrosive gases. In the first class is the precision Simmance-Abady CO<sub>2</sub> recorder, so-called because it periodically analyzes samples of flue gas for the per cent of carbon dioxide which they contain and records

CWG, purified gas and gases in retort settings. Where the gas is under pressure a governor is fitted at the inlet, and a burner is also supplied for combustible gases.

Recorders are also built for ranges other than 20 per cent, as, for instance, 0 to 35 per cent, and 0 to 50 per cent for lime kiln control in beet sugar factories, etc.; also such high ranges as 0 to 100 per cent, 65 to 100 per cent and 80 to 100 per cent for special chemical machinery. The latter need a strong solution and require about ten minutes for a complete absorption of the CO<sub>2</sub> by the KOH, as compared with about three or four minutes with a weaker solution in the low per cent recorders. Furthermore, it is occasionally necessary to draw the gas sample against a high draught, and one recorder is now in operation in a large manufacturing plant where it is drawn against a maximum of 18½ in. water vacuum. A high percentage recorder for chemical works is shown in Fig. 1.

In the second class are the recording analyzers for corrosive gases, such as SO<sub>2</sub>, HCl and chlorine gas, and which are used in paper mills, acid works, etc. They are built to record various per cents as are the CO<sub>2</sub> recorders, and operate on the same

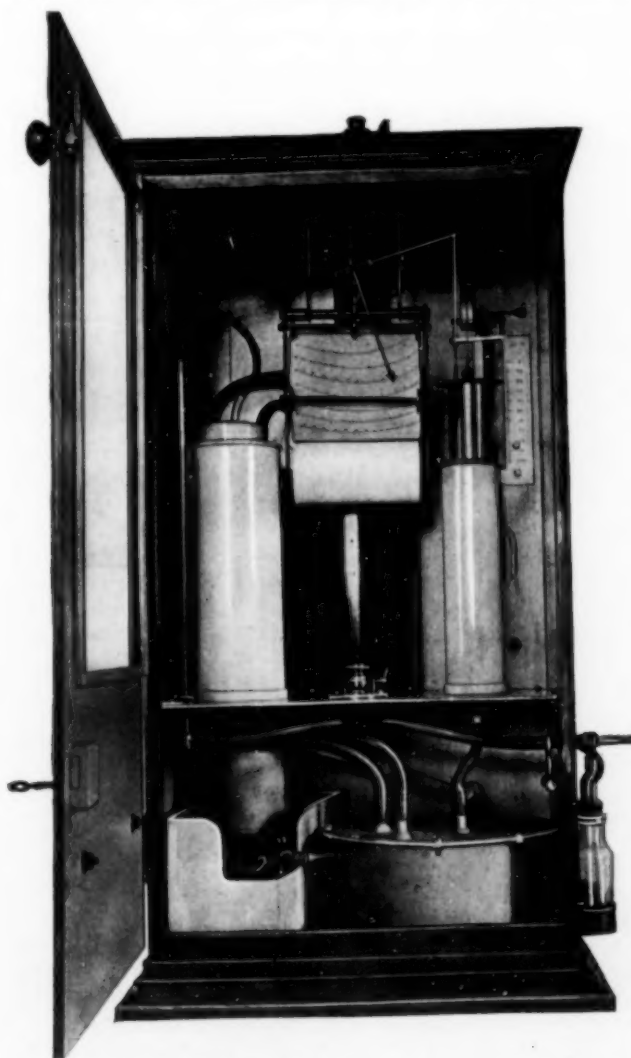


FIG. 1.—HIGH PERCENTAGE RECORDER FOR CHEMICAL WORKS.

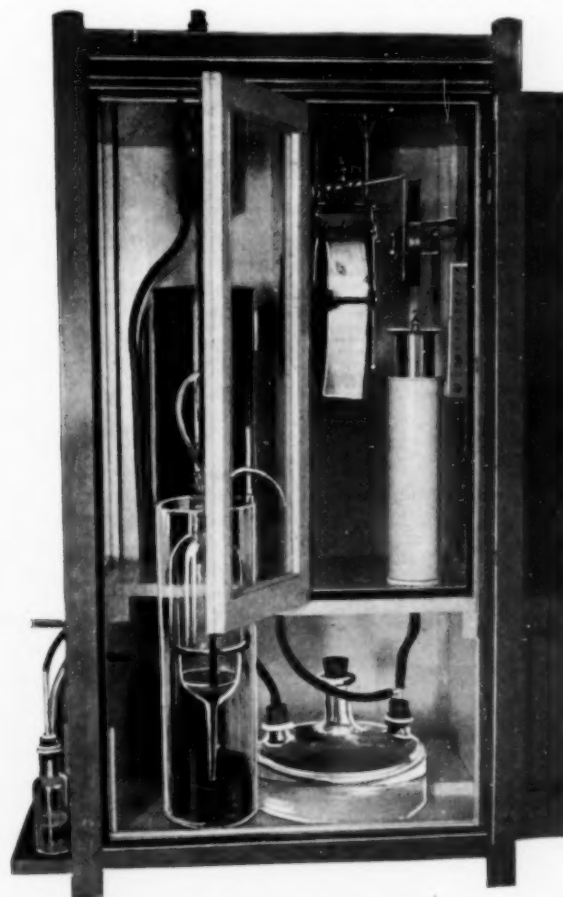


FIG. 2.—RECORDER FOR CORROSIVE GASES, SUCH AS SO<sub>2</sub>, HCL, CHLORINE, ETC.

this percentage on a chart, showing graphically and at all times of the day or night the completeness or incompleteness of combustion. The boiler house CO<sub>2</sub> recorder is perhaps the most thoroughly discussed of all automatic analyzers, for the reason that it is an established fact that a high percentage of CO<sub>2</sub> in the flue gas is one of the principal factors in economical combustion.

As the theoretical maximum of CO<sub>2</sub> in burned fuel gases is about 20 per cent, the charts for the five standard types of boiler-house recorders are graduated from zero to 20 per cent. Charts may be disc, drum or tape charts. These standard types may be used on furnaces fired with natural gas; they are also used for recording the percentage of CO<sub>2</sub> in producer gas,

general principle. The main difference in the construction is that the parts which handle the gases, including extractor bell and tank and solution vessel, are made, not of metal, but of glass, to withstand the corrosive action of the gas. Also on account of the fumes from the gas the indicating and recording mechanism is contained in an air-tight compartment. A view of the recorder for corrosive gases is shown in Fig. 2.

Generally speaking, the recorder may be called an automatic chemist. Samples of gas are drawn into a waterjacketed burette called the extractor bell *d*, Fig. 3, where the sample is cut off and the gas reduced to atmospheric pressure. The recorder is thus independent of varying draft conditions. The bell is water sealed and open at the bottom, and gas is drawn

in by means of the vacuum created in the bell when the latter is raised. After the complete sample is drawn into the bell, cock *h* automatically closes and the bell starts to sink; pressure is built up in the bell, which forces the gas through the caustic solution in tank *m*, where the carbon dioxide is absorbed. The balance of the gas passes into the recorder bell *j*, which rises to a point on the scale indicating the volume of gas that has been absorbed. A pen then marks on the chart the same per cent of absorption as is indicated on the scale, after which the bell vents through cock *h*.

The motive power which operates the extractor bell is a float *b* rising and falling in the siphon tank *a*. A constant stream of water flows through cock *x* at the top of the recorder and into tank *a*. When float *b* rises to the top of the tank, valve *e* is tripped, allowing to come into the tank a flush of water which immediately siphons out of the tank through *g*, allowing float to sink and raising extractor bell.

This same stream of water which is the motive power actuates an injector below the inlet cock, and this injector brings

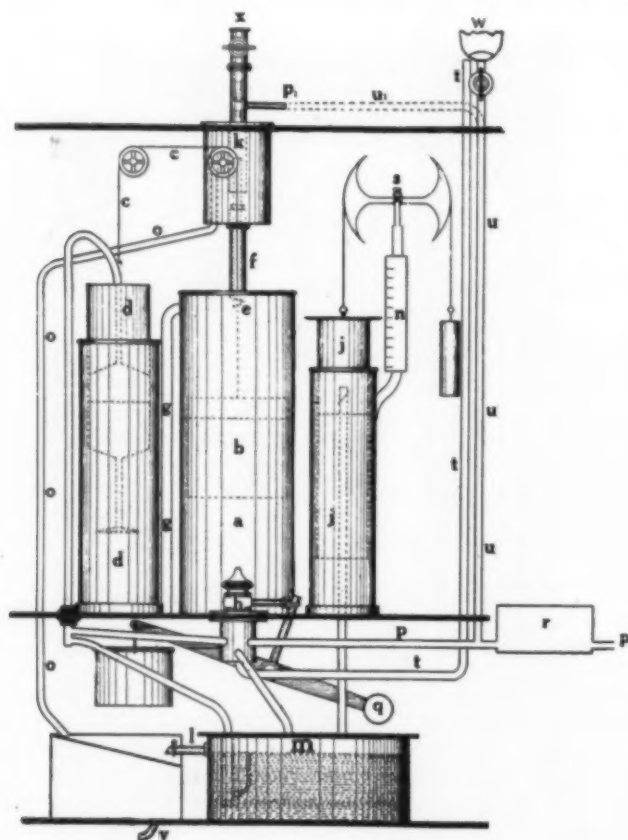


FIG. 3.—DIAGRAM OF CO<sub>2</sub> RECORDER.

along a constant stream of gas through auxiliary connection *p*, so that there is no dead gas in the sampling pipe.

In boiler-house service there is practically no "lag," the operations of the recorder being about three minutes behind the actual operations in the furnace. The cycle of operations is completed in about three minutes in the boiler-house recorder, whereas for gas containing higher percentages of CO<sub>2</sub> the cycle may take as much as ten minutes, owing to the longer time taken for absorption.

For recorders handling non-corrosive gases, such as flue gas, all the working parts are made of metal and are enclosed in a metallic case, so that it is suitable for use in exposed situations.

To the gas inlet nozzle are attached two tell-tale bottles, one of which shows that the stream of gas is flowing constantly, and the other indicates when the sampling pipe is plugged with

soot or other material. When used on a battery of boilers a pair of oil cups is located at each boiler, these oil cups taking the place of cocks or valves; to take records from any particular boiler in the battery a dust filter is shifted along by hand from one boiler to the next.

The recorders have been frequently tested by the best authorities, including chemists of some of the largest plants, and invariably check up to within one-half of 1 per cent or less of the most exhaustive hand analyses, and this under varying conditions of draft.

### A New Electrolytic Cell for Hypochlorite Solutions.

By R. H. PEARSALL.

Chlorine is to-day used in the large majority of bleaching processes and is also coming more and more into use for sterilizing water. Its value for bleaching is well known, and it may be pointed out here that it is so powerful a sterilizing agent that as small a quantity as one part in one million is enough to entirely destroy the bacilli of typhoid and diphtheria in one minute, even in bad water.

Chlorine is generally used in the form of chloride of lime, or bleaching powder, as this is cheap and portable. But this has the disadvantage that it leaves a residue of lime which is a cause of decay in fibrous materials which have been bleached. The powder is highly poisonous and, moreover, does not retain its valuable properties long after exposure to the air with the consequence that where smaller quantities are needed, as for water sterilization, it is difficult to maintain stocks of powder in good condition and at the highest efficiency.

This involves larger doses for sterilization purposes in order to be certain of results and irregularities in the quality of the powder result in the water occasionally tasting or smelling of chlorine.

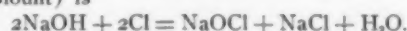
An improved method which entirely avoids this is to use a solution of hypochlorite which as made to-day will retain practically its full strength for long periods, and is much more powerful in its action than bleaching powder. It has the further advantage that it forms no deposit in the pipes, valves, etc., as does the bleaching powder solution, so that much greater regularity and reliability of action is secured.

As it is most economically made in weak solutions containing from ½ per cent to 2 per cent of available chlorine, it is preferable to make the solution on the spot as it is required, a process which has become very simple and economical by virtue of recent improvements in electrolysis which are described in this article.

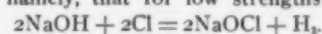
We may describe the principles of the formation of hypochlorites by electrolytic means. If a current is sent through a solution of sodium chloride in water the chloride is split up into the component parts sodium and chlorine. The chlorine is liberated at the anode and the sodium at the cathode, forming by reaction with the water sodium hydroxide and hydrogen.

In the manufacture of chloride of lime and caustic soda the products at the electrodes are kept separate, the chlorine being drawn off to lime beds and the caustic soda being withdrawn at the other electrode. In the manufacture of hypochlorite solutions, on the other hand, the liberated chlorine and sodium hydroxide have to recombine to form the hypochlorite NaOCl.

A widely accepted explanation of this reaction (due to Mr. Bertram Blount) is



A different view is, however, held by the inventor of the new form of cell for this purpose, Mr. W. Pollard Digby, of London, England, namely, that for low strengths the reaction is



His reasons for favoring this most simple hypothesis are two-fold.<sup>1</sup> Firstly, the large number of authenticated cases in

which the electrochemical efficiency of production has not been 50 per cent or under as would agree with the first hypothesis but upwards of 80 per cent or 90 per cent, and secondly, when the reaction takes place under special control there is a gaseous evolution on the mixture of the anodic and cathodic products.

In early forms of cell two electrodes were immersed in the electrolyte and the current switched on. Trouble was met from the cathodic hydrogen which with heavy current densities rose in a constant stream from the electrode and caused discomfort to the workers. In this class of apparatus the reunion of the anodic and cathodic products is a haphazard affair depending wholly upon the circulation of the main body of the electrolyte in which the recombination takes place.

It is also found that the electrochemical efficiency of the cell depends upon the richness of the solution in hypochlorite. That is to say that as the proportion of hypochlorite rises the efficiency falls. The consequence is that in order to avoid undue waste of electric energy it has been necessary to draw off the electrolyte when it has reached only a low hypochlorite content and has still a large salt content. In other words, it has been necessary to waste salt in order to save current, and this in large quantities.

For instance, at Maidenhead, England, when the hypochlorite solution produced contained about 3.5 grams of available chlorine per liter, the amount of sodium chloride present was about 6.5 per cent. That is to say, each gram of available chlorine produced carried with it over 18 grams of salt. In other words, only one-twelfth of the chlorine initially present in the salt became available in the hypochlorite form.

This difficulty has been got over in the new cell referred to above, known as the Digby electrolyzer.

In this cell the manner in which the anode and cathode products recombine is controlled so that the body of the electrolyte is not altered in composition and the electrochemical efficiency is maintained while drawing off a hypochlorite solution with a very small saline content.

The principle of the cell may be explained by considering a cell with two carbon electrodes separated by two porous diaphragms—in this case of asbestos. The diaphragms divide the cell into three portions, the two end ones being connected together by a glass tube and separated from the middle space.

The electrodes are placed in the end portions which are designed to fit them with but small clearance, while the main body of electrolyte is in the middle portion. When the cell is working caustic soda is formed at the cathode end and the consequently denser solution passes by gravity through the glass tube to the anode compartment where chlorine is being liberated. Thus the caustic soda is brought directly to be acted upon by nascent chlorine.

The main body of electrolyte in the middle portion of the cell is a saturated salt solution for better conductivity. The solution which replenishes the cathode compartment may be pure water or a dilute alkali solution, as sodium carbonate.

The ions migrate under the influence of the current, the chlorine to the anode and the sodium to the cathode and the caustic solution there formed passes round to the chlorine without taking any appreciable amount of salt with it to be wasted, while at the same time the body of the electrolyte remains a salt solution pure and simple, and the electrochemical efficiency is maintained.

In practice these cells are made with three or five plates, arranged in series, and channels connect the different elements of the whole cell so that the anode reaction takes place on the side of the middle plates and the cathode reaction on the other.

The most economical current density to employ depends on the relative cost of electric energy and brine in the district in question, and the cells are worked at this density, while the strength of the resulting solution is controlled entirely by regulating the rate of inflow of water to the cathode end. The main electrolyte is kept a saturated solution with excess of salt, and more salt is added as this excess is absorbed.

In previous cells it has been found necessary to cool the electrolyte artificially in order to maintain stability in the reactions, and Mr. Digby, in his patent, refers to arrangements for cooling the caustic solution as it passes on its way to the anode. But in practice it has been found unnecessary to use artificial cooling in this type of cell, the anode and cathode portions being directly connected by short ducts.

The Digby electrolyzer is remarkably simple and inexpensive in its construction. The ends are formed of slate slabs and the partitions of asbestos sheet. The sheets are separated by slate distance pieces and the whole bolted together while the carbon electrodes are fitted into their proper elements.

In some cases the slate has been replaced by wood suitably treated with tar to further reducing the cost of the cell. There are no moving parts and the whole action is perfectly simple, with practically no possibility of getting out of order. Should dirty brine be used for economy the cell may be periodically scoured out with a jet of water without disturbing any mechanical connection in any way.

Cells with two elements in series are made to work on a pressure of 10 volts and to give an output of half a pound of available chlorine per 24 hours when taking 7 amperes. Such a cell complete costs about \$200.

### A Boiler Plant Waste Meter

It has been thoroughly demonstrated that waste of heat in boiler plants may be greatly reduced by more careful attention to what is going on in the furnace. As with the improvements which have been obtained in the engine-room by the use of the indicator, the thermometer, the steam gage, and in the use of electrical measuring instruments, so in the boiler plant the measurement of coal and water on scales or by meters, and the measurement of waste by a CO<sub>2</sub> recorder result in considerably decreasing the cost of power production.

On the average it may be stated that only 60 per cent of the heat in the coal enters the boiler; 40 per cent is wasted. Of this 40 per cent the total waste is distributed about as follows: Loss in radiation, 5 per cent; loss in soot and smoke, 1 per cent; loss represented by actual loss of coal through the grates, 2 per cent; loss due to combustion of the carbon to carbon monoxide instead of dioxide, 2 per cent; heat carried away by the chimney gases due to their temperature, 30 per cent.

The amount of coal waste due to loss of heat up the stack is quite fully realized, as is the fact that considerable reduction may be obtained in the extent of the chimney loss by measurement of carbon dioxide. The relation between per cent carbon dioxide and heat lost may be shown diagrammatically by the chart of Fig. 1. The areas in each case are proportional to the amount of heat wasted, and as these areas are reduced by decreasing the excess air, the per cent of CO<sub>2</sub> is increased.

The CO<sub>2</sub> recorder was thus devised to automatically inform the engineer of the amount of waste occurring. The CO<sub>2</sub> measurement gave an indication of how much air was being used per pound of coal, the most important item in determining the amount of loss in the waste gases going up the chimney. The other important item, the temperature, is taken by pyrometers, mercury thermometers or other means.

Caustic potash absorbs carbon dioxide. This is the fundamental principle of all instruments for making a measurement of CO<sub>2</sub>. In the older types of automatic recording instruments bells or jars for measuring the gases before and after the CO<sub>2</sub> was absorbed were used. The difference in volume of the gas before and after the CO<sub>2</sub> was abstracted gave a measurement of carbon dioxide in the gases. Valuable as they are, such instruments have, however, certain limitations.

If, instead of measuring the per cent carbon dioxide by measuring the actual volume of a given amount of gas before and after the carbon dioxide has been abstracted from it, the pressure of the gas is measured, then the change in pressure of the gas due to the reduction in its volume when the CO<sub>2</sub> is



absorbed will give a ready and reliable method of measurement.

The diagram of Fig. 2 shows how this principle is employed in the Uehling waste meter for measuring both percentage of carbon dioxide and temperature. Gas is drawn through the apparatus continuously by a small steam aspirator. Between the

ure temperature it is evident that a very effective combined  $\text{CO}_2$  machine and temperature machine or waste meter is built on this principle. In measuring temperature, instead of the change in vacuum being produced by absorbing part of the gas between the apertures, change in vacuum is secured by reason of the

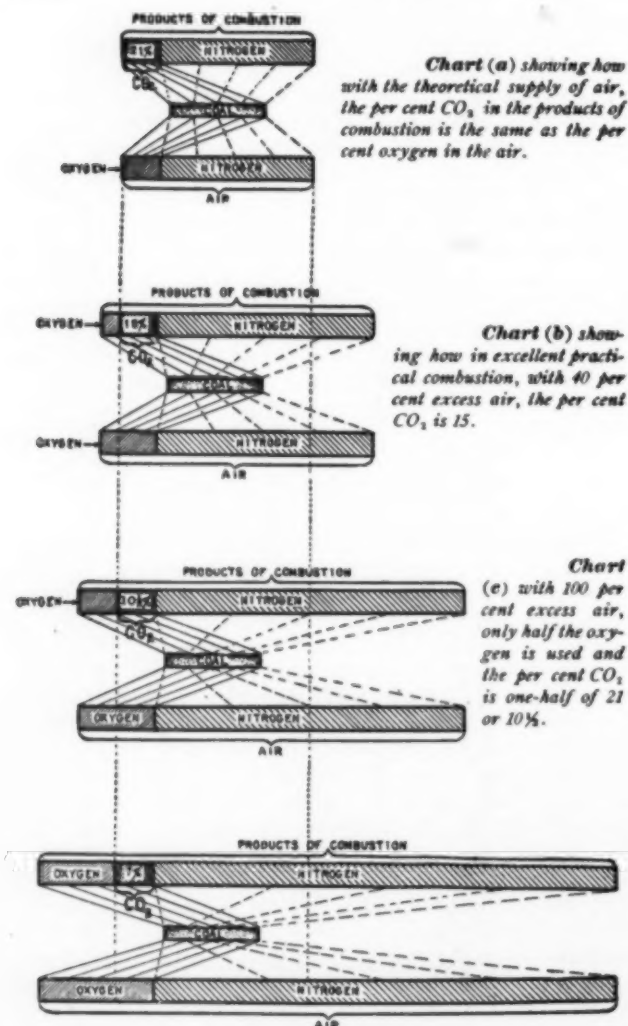


FIG. 1.—CHARTS SHOWING THE CONDITIONS FOR DIFFERENT PERCENTAGES OF CARBON DIOXIDE.

two apertures—that is, in the chamber marked C—the carbon dioxide is absorbed (in the case of the carbon-dioxide instrument) and thus the volume of the gas between the apertures is reduced by an amount depending upon the amount of  $\text{CO}_2$  present. Any reduction in the volume of the gas between the two apertures increases the vacuum. These changes are proportional to the amount of  $\text{CO}_2$  absorbed and thus the suction or partial vacuum forms a basis for indicating and recording variations in carbon dioxide in flue gases.

The indicating instruments are simply columns properly calibrated and are supplied at the machine proper and also as shown in Fig. 3 for the front of the boiler. The indicators at the boiler front are found to be most useful in that reference can be made continuously to them, whereas the recording charts are more valuable as permanent records and records from which to obtain average results with different kinds of coal, different grate area, different drafts, etc. The recording instruments may be placed anywhere and any number of them may be used as all they do is to record the partial vacuum or suction.

As the same principle and similar apparatus is used to meas-

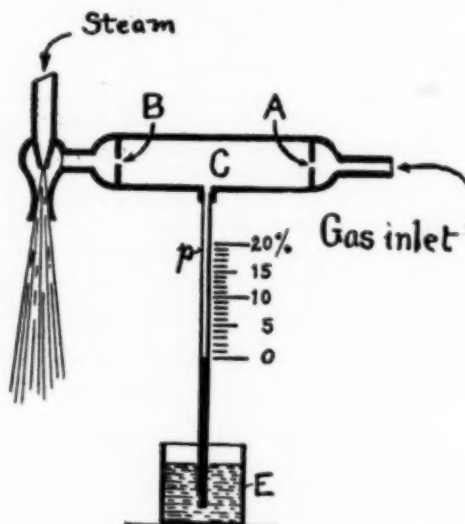


FIG. 2.—PRINCIPLE OF WASTE METER.

difference in temperature between the two apertures. One aperture is in a nickel tube placed in the flue and the other is maintained at a constant temperature by exhaust steam.

The appearance of a combined instrument of this type may be seen in Fig. 4, a photograph of a Uehling waste meter in-

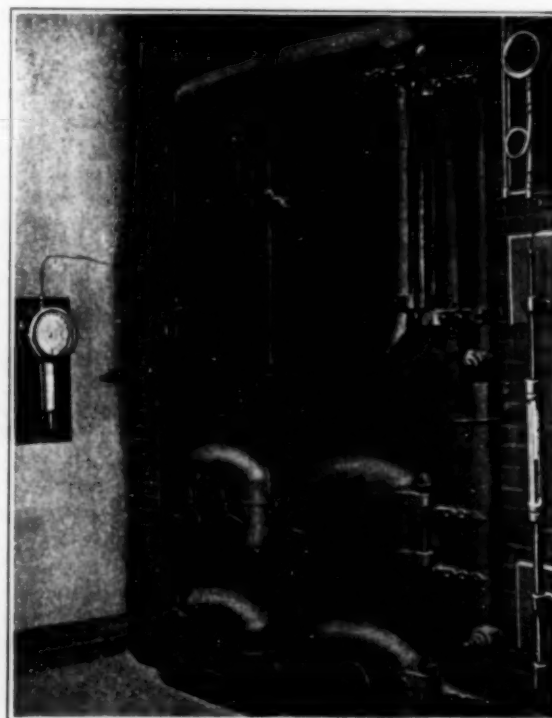


FIG. 3.—BOILER WITH  $\text{CO}_2$  INDICATOR AT RIGHT AND DRAFT RECORDER AT LEFT.

stalled in the plant of Robert Gair Company, Brooklyn, N. Y. Here the two indicating columns for per cent carbon dioxide and for temperature may be seen at the front of the instrument proper, while on the board are the recording gages for temperature and carbon dioxide. These are at the left and right. In the boiler-room proper is placed the  $\text{CO}_2$  indicator.

### Carbon Tetrachloride as Fire-Extinguisher.

The cheap electrolytic preparation of chlorine from brine has greatly reduced the cost of making carbon tetrachloride, a highly-valued solvent for fats and oils, so that it can even be used as a fire-extinguisher, as noticed in London *Engineering* of April 28.

Various compounds of carbon with chlorine and with the other halogens, fluorine, bromine, and iodine are known, and they are regarded as derived from methane (the fire-damp of the miner),  $\text{CH}_4$ , in which the hydrogen atoms are replaced by halogens. When one or three atoms of hydrogen are replaced, the resulting compounds are anæsthetics producing sleep (especially chloroform,  $\text{CHCl}_3$ ) or antiseptics (iodoform  $\text{CHI}_3$ ). Several of the other compounds are important in the dye industry; but, with the exception of the fluoride  $\text{CF}_4$ , none of them can be prepared by the direct union of the elements.

The tetrachloride is a colorless liquid, characterized by a pleasant smell, recalling that of Rhine wine; it freezes at  $-25^\circ$  Cent. and boils at  $78^\circ$  Cent., but the vapors are practically non-inflammable and non-explosive and stifle combustion, and the carbon tetrachloride thus occupies an exceptional position.

Various processes for the preparation of the tetrachloride have been patented in recent years, especially after Edward R. Taylor succeeded in making as much carbon bisulphide from coal and sulphur in his simple electric furnace as the United States requires. According to J. A. Robinson, who drew attention to carbon tetrachloride in the *Quarterly* of the National (American) Fire Association in January last, the tetrachloride is made by passing chlorine gas over heated carbon bisulphide. The condensed products contain carbon tetrachloride and sulphur dichloride; the latter is decomposed by the injection of caustic soda, and the tetrachloride is purified by distillation. It is put on the market in 100-gallon drums; the density of the

In the oil and fat industry mixtures of carbon tetrachloride and naphtha are used, and it is interesting to note that, according to E. A. Barrier, the addition of tetrachloride would make the naphtha safe against fire and explosion. Considerable percentages of the tetrachloride would, however, be wanted. A naphtha distilling at about  $55^\circ$  Cent. should contain 30 per cent of carbon tetrachloride. A motor gasoline ( $70^\circ$  Cent.) should be mixed with 50 per cent of tetrachloride to be free from explosion hazards, and with 60 per cent to be free from fire hazard; but in all these cases an additional 5 per cent of tetrachloride would technically be considered advisable.

The continued contact between hot carbon tetrachloride and water or water vapor should not cause direct dangers. The resulting products would be carbon dioxide and hydrochloric acid, not pleasant, yet not particularly dangerous gases. But it would be rash to predict that no other reactions might take place during a large fire; carbon oxychloride (sometimes called phosgene, because it is formed when carbon monoxide and chlorine are exposed to sunlight) might also be liberated, *e.g.*, in highly unpleasant vapors, which water would decompose into carbon dioxide and hydrochloric acid.

### Tests and Analyses.

The Electrical Testing Laboratories, Eightieth Street and East End Avenue, New York City, which in the past confined their activities chiefly to testing work in the electrical and illuminating engineering fields, have recently extended their equipment so as to include coal testing, paper testing, tests of structural materials and thermometer tests.

Both chemical and calorimetric analyses of coal are made. An At-water calorimeter and an Emerson calorimeter (both bomb types) are available. All thermometers used have

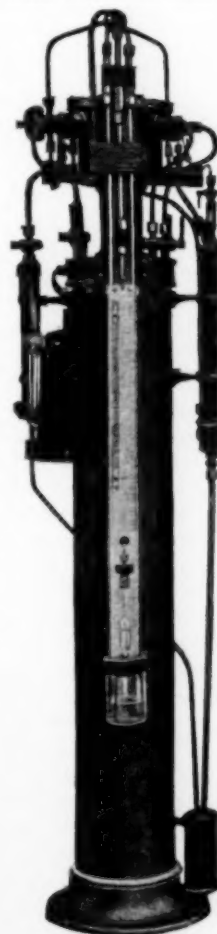


FIG. 5.—UEHLING WASTE METER.

been calibrated by the Bureau of Standards at Washington, as also has the standard combustible which is used to standardize the calorimeters.

For paper testing special apparatus has been installed, to determine the material from which the paper is made, various physical properties such as bursting strength, tensile strength, folding strength, etc., and certain facts of a chemical nature such as kind of size and filter, amount of ash, presence of acid, chlorine, etc.

For testing structural materials a 200,000-lb. testing machine has been installed for tension, compression and transverse testing of steel, iron, brick, stone, concrete, timber, etc. A torsion testing machine of 230,000 in.-lb. capacity has also been provided. The machine is capable of taking specimens from 6 in. to 20 ft. in length, and up to  $3\frac{1}{2}$  in. in diameter. This equipment together with the smaller machines already installed enables the Electrical Testing Laboratories to make any of the usual tests on materials used in industrial and structural enterprises, such as wire, cable, rope, chain, belting, iron, steel, alloys of various kinds, building materials, etc. A complete equipment for making and testing cement briquettes according to standard specifications has also been installed.

For the thermometer department special apparatus has been

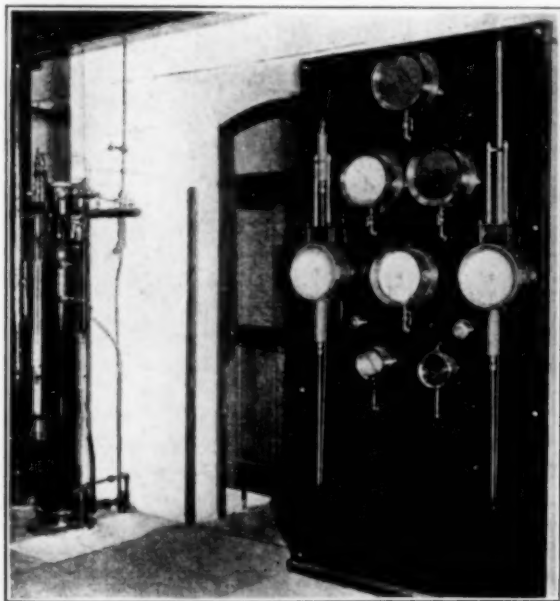


FIG. 4.—INSTALLATION OF WASTE METER IN PLANT OF ROBERT GAIR COMPANY IN BROOKLYN.

compound is 1.604, and the pound costs about 10 cents (5d.).

Fire-extinguishers filled with tetrachloride have been used by the Interborough Rapid Transit Company of New York on their cars. It has been pointed out that carbon tetrachloride, being a non-inflammable and non-corrosive substance, would be preferable to water and sand for extinguishing undesired arcs in electric installations. While no electrical engineer would probably resort to water in such a case, yet the tetrachloride may be useful.

built for the testing of thermometers of all kinds used for industrial purposes up to 500° C. and also for testing clinical thermometers. All apparatus has been built similar to the Government standard apparatus at Washington and the methods used are also the same. The standards employed by the Electrical Testing Laboratories are those of the Bureau of Standards in Washington, D. C.

### NOTES

**The Abbe Engineering Company**, of 220 Broadway, New York City, has removed its office from the twelfth to the eleventh floor of this building, since their rapidly growing business in tube mills, pebble mills and ball mills required an enlargement of their quarters.

**The American Gröndal Company** is the new name of the American Gröndal-Kjellin Company. This change of name has been made in connection with the broadening out of the scope of their work in concentrating and briquetting low-grade iron ores. The company will conduct complete commercial tests on any ore submitted in its testing plant, and, from the results of such tests, make a proposition for the proper method of treating the ore, design the plant, and if so desired, supervise the installation.

**Vanadium.**—Ever since the formation of the American Vanadium Company the entire product of vanadium alloys produced by this company has been marketed by the Vanadium Sales Company of America. The offices of both companies have been in the Frick Building, Pittsburgh, Pa., and their products, especially ferrovanadium, have been sold in every manufacturing country in the world. Recently the Universal Vanadium Company has been formed for the purpose of acting as selling agents for the American Vanadium Company in a more comprehensive and effectual manner, and it will act in a selling capacity in conjunction with the Vanadium Sales Company of America, both companies taking charge of the entire product of the American Vanadium Company.

**The National Carbon Company**, of Cleveland, Ohio, has just issued a publication entitled "Practical Operation of Arc Lamps." It is full of useful instructive information for the use of lamp owners and operators. A carefully prepared alphabetical index deserves special mention.

**Earthenware Apparatus.**—Hard, white vitreous earthenware and porous earthenware are finding increased use in chemical and electrochemical work. Messrs. John Maddock & Sons, of Trenton, N. J., who make a specialty of the manufacture of such earthenware apparatus (which should not be confounded with chemical stoneware), make these goods from either white porous clay or a white vitreous body, either glazed or unglazed, with a transparent glaze. They are making large quantities of white vitreous battery jars and also large quantities of round porous cups, there being practically no limit to their size. They also make quantities of special porous oblong boxes.

**Spray Nozzles.**—The Buffalo Forge Company, of Buffalo, N. Y., have sent us their pamphlet on Buffalo spray nozzles and strainers. As is well known, the spray nozzle gives an exceedingly fine spray with a minimum water pressure. Operating at pressures as low as 15 lb. the centrifugal action of the nozzle produces an atomizing effect which is further increased with the increase in pressure. The greatest atomizing effect is obtained at a pressure of about 40 lb. The successful results obtained with these nozzles are due to the fact that the water enters the circular chamber tangentially, receiving a whirling motion, and is not obstructed in any way until its exit through the opening in the disk. As it approaches this opening an increase of velocity is caused by the change in the shape of the passage until it bursts into an atomized spray, which does not depend for its fineness on the small size of the orifice. For this reason large water passages are used throughout, with con-

sequent freedom from clogging. The nozzle is made in two parts. The cap can be replaced if the action of the liquid is such as to corrode the metal and destroy the effectiveness of the spray. While regularly furnished in brass, the Buffalo Forge Company makes these nozzles in large or small quantities of any material desired, like lead or brass. It is particularly interesting to note that monel metal nozzles have replaced others in producer-gas power plants, blast furnaces and chemical plants.

**The Ashland Fire Brick Company**, of Ashland, Ky., is sending out a series of very clever bulletins which impart interesting information in an easy conversational style. From one of them we learn that the flint clay from which their brick is made is permitted to weather in the yards for six months before it is used. Clay when it comes from the mine is very hard and brittle, but weathering grinds it to fine particles and many of the impurities are washed away. The result is a better and smoother brick.

**Casting Alloys** is the title of a pamphlet recently issued by the Lumen Bearing Company, of Buffalo, N. Y. The different bronzes made by this company are classified according to their uses and concisely described as to their properties. For chemical and metallurgical purposes their alloy No. 0 is particularly interesting. It is a copper-tin acid-resisting bronze, for pump bodies, valves and other parts coming in contact with fluids containing alkaline or acids. Its tensile strength is 50,000 lb.; specific gravity, 9.05; weight per cubic inch, 0.3258 lb.; the shrinkage in sand molds,  $\frac{1}{8}$  in. per foot.

**Transvaal Gold Production.**—The number of companies reporting to the Transvaal Chamber of Mines in February, 1911, was 69. The total tonnage milled during that period was 1,749,834 tons of ore; 9627 stamps were in operation with an average duty of 7.5 tons per 24 hours. Tube mills in commission numbered 201. The yield for the month was 610,828 fine ounces gold. The number of tube mills in operation shows an increase of 30 per cent as compared with February, 1910.

**Chas. C. Moore & Company**, engineers, San Francisco, Cal., and the Pacific Coast managers of the Babcock & Wilcox Company, have recently prepared for distribution among the engineering fraternity a notebook specially designed for the convenience of those who have to keep many individual notes and memoranda. One of the books and extra inserts (the memoranda being detachable) can be obtained by addressing the company.

**The Utah Society of Engineers** held its annual dinner at the Commercial Club, Salt Lake City, on April 20, 1911. Addresses were made by John Dern, president of the American Mining Congress, and various other members of the society. The officers for the ensuing year were elected as follows: President, M. D. Grosh; first vice-president, C. F. Moore; second vice-president, E. H. Beckstrand; secretary, R. B. Ket-chum; treasurer, A. S. Peters.

**The General Engineering Company**, Salt Lake City, Utah, has recently moved into new quarters, where it has one of the most complete ore-testing plants in the West. Tests by concentration, cyanidation, amalgamation, flotation and magnetic concentration can be made on lots of ore ranging in quantity from 50 lb. to a carload. The company also has put in a complete cement testing laboratory.

**The Ohio Copper Company**, Lark, Utah, is putting in 60 Deister No. 3 concentrating tables to handle the slime. This change is expected to put the Ohio mill in a better position to save fine mineral and will also materially increase the capacity.

**In conveyor belt installations** some of the features which require attention are the thickness, width, material, and cover of the belt, the spacing of the carriers, the speed of the belt, and the proper feeding of the materials to be conveyed. These features vary with almost every installation, and should be determined specially for each plant.



### Personal

**Mr. J. M. Callow**, of the General Engineering Company, Salt Lake City, has been appointed consulting metallurgist for the Inspiration Copper Company.

**Mr. Francis E. Drake**, who for several years has been the managing director of the Société Anonyme Westinghouse of Paris and Havre and principal officer in several of the Continental Westinghouse interests, has resigned from the active management of these properties to occupy himself with certain private interests, and, after a period of rest and recuperation, will establish his office at No. 16, rue Halevy, Paris. Mr. Drake is well known, not only in electrical, but in metallurgical circles, since before he went to Europe he was the president of the Lanyon Zinc Company and it was under his presidency and direction that the first experiments in electric zinc smelting in America were carried out by his company. Mr. Drake is interested in several electric enterprises in Europe and will carry out, as engineer and contractor, certain tram and railway lines now in process of development. The efforts of Mr. Drake in behalf of electric traction, especially in the direction of single-phase development and for other aid rendered to French industries, recently received the recognition of the French government in the shape of promotion to the rank of Officer in the Legion of Honor. Mr. Drake is a member of the Engineers' Club and a life member of the American Chamber of Commerce in Paris; he is also a member of the American Electrochemical Society.

**Dr. W. C. Ebaugh**, professor of chemistry in the University of Utah, has been granted a year's leave of absence for 1911-12.

**Mr. J. R. Finlay**, formerly with the Goldfield Consolidated Mining Company, Goldfield, Nev., has opened offices at 52 William Street, New York, as a consulting engineer.

**Mr. A. I. Goodell** is acting as Northwestern representative for the International Smelting & Refining Company.

**Mr. Philo D. Grommon** has been appointed superintendent of the mines and mill of the Ophir Gold Mines Company, Ophir, Col.

**Mr. H. R. Holbrook**, formerly employed by the Balaklala Copper Company, at Coram, Cal., has accepted a position as chief chemist for the Mexican-American Smelting & Refining Company, at Guaymas, Sonora, Mexico.

**Mr. Theodore P. Holt** has been appointed assistant professor of mining and milling in the University of Utah, where he has been an instructor since his graduation.

**Mr. J. E. McAllister**, until recently general manager of the British Columbia Copper Company, has resigned and will enter consulting practice in New York.

**Mr. A. H. Prior**, who has been cyanide superintendent of the Rio Plata Mining Company, has been appointed general superintendent, vice H. W. Edmondson, resigned.

The wedding is announced, on June 1, of **Mr. Hugh Rodman**, of the Rodman Chemical Company, of Pittsburgh, with Miss **Mary Bynum Iarnagin**.

**Mr. Benjamin B. Thayer**, president of the Anaconda Copper Mining Company, recently made his annual trip of inspection to the mines and reduction works of the company in Montana.

### OBITUARY

**James B. Daniels**, general manager of the milling department of the Portland Gold Mining Company, Colorado Springs, Col., died on April 3, 1911, following an operation for appendicitis performed four days previously. Mr. Daniels had been identified with the metallurgical industry in Colorado since 1879, when he came to Leadville and entered the old Harrison

Reduction works, which was one of the early smelters in that city. From that time until 1903 he was connected with smelters at Denver and Pueblo. Later he left the lead-smelting industry and entered the employ of the Portland company, which is engaged in the treatment of Cripple Creek ores by the chlorination and cyanide processes. Mr. Daniels died at the age of fifty-one, and is survived by a widow. He was highly esteemed by the officials of his company, who regarded him as a large factor in the success of their operations. He was greatly interested in the new process which the company has in operation at Victor, and was instrumental in bringing it to a successful conclusion.

**Samuel F. Emmons**, eminent geologist and pioneer in the economic branch of that science, died in Washington, D. C., on March 28, 1911. His last illness was of but five days' duration, but for a year or two previous he had been in poor health. Mr. Emmons was probably the foremost geologist in his country, and was widely known throughout the West, where his most important work was done. He was one of the first to apply the science of geology to mining, and his work in that line has led to the most remarkable mining developments which have been known in the United States. Especially was his work on the mining and geology of Leadville a masterly production and his greatest work. This was undertaken for the United States Geological Survey, in which organization Mr. Emmons was a leader for many years. His first connection with government work was in 1867 when he accompanied the United States Geological Exploration of the fortieth parallel. He made many contributions to the published reports of this expedition, and has been a noted contributor to the various publications of the Survey. As a member of many scientific societies he was always active in their interests and received many honors at their hands.

**Mrs. Ellen H. Richards**, wife of Prof. Robert H. Richards, of the Massachusetts Institute of Technology, died at Boston March 30, 1911, after a week's illness. Mrs. Richards was instructor in sanitary chemistry at the institute, from which also she was a graduate in 1873. In 1875 she married Professor Richards, who is at the head of the department of mining and metallurgical engineering, and together they continued on the instruction staff of the institute until the time of her death. It is given to few women to hold as prominent a position in the technical world, and live a life of such useful service as fell to the lot of Mrs. Richards. Especially in the application of science and scientific methods to social and domestic economy she was very active and helpful. In her later years she acquired an international reputation, and was honored at home by receiving the doctor's degree from Smith College. She was a member of many scientific societies and the author of important works on chemistry.

### Digest of Electrochemical U. S. Patents.

Prior to 1903.

*Arranged according to subject matter and in chronological order.*

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#### ORE TREATMENT (Continued).

351,576, Oct. 26, 1886, Henry R. Cassel, of London, County of Middlesex, England, assignor to the Cassel Gold Extracting Company (Ltd.), of Glasgow, Scotland.

Gold, etc. Ores or alloys are powdered and charged into an anode compartment separated from the cathode compartment by a diaphragm of asbestos. Metal is dissolved in the anode compartment and precipitated at the cathode. The apparatus illustrated comprises a stationary tank containing a revolving drum, constituting the anode compartment. The circumferential wall of this drum is of asbestos cloth, having a removable portion to admit the charge. A series of carbon anode rods are arranged in a circle within it, extending hori-

zontally through the end walls of the drum. The drum is surrounded by a tubular sheet-metal cathode, in two halves. Illustrates a specific connection for carrying the current through the revolving drum shaft to the anode. The anode compartment contains the chloride solution, and the drum is preferably submerged in the electrolyte in the tank.

257,659, Feb. 15, 1887, Desmond Gerald Fitzgerald, of Akerman Road, Loughborough Road, Brixton, County of Surrey, England.

Gold. Employs anodes of lead peroxide for electrolytically generating chlorine. The anode may be molded of a plastic mixture of lead oxide and ammonium sulphate or chloride, e.g., being plastered onto the inner surface of the cell as a lining. Prefers, however, to build up the anode from slabs, plates, tiles, fragments or granules of a molded mixture of litharge and ammonium sulphate, or hydropotassic or hydrosodic sulphate, peroxidized by a hypochlorite solution and set in the plastic lead peroxide mixture. The terminal is a plate of platinum embedded in the upper part of the anode. The cathode may be a plate of copper. Illustrates a cell consisting of a shallow tank of slate or brick, with suitable lining, the anode being formed as a tray lying in one side of the tank, while the cathode is a copper tray coated with insulation at the other side. May use plates of lead peroxide as anodes, alternating with suitable cathodes, to produce hypochlorites or chlorates.

359,156, March 8, 1887, Jean Antoine Mathieu, of Detroit, Mich.

Treats lead ores, e.g., carbonates containing gold and silver, by crushing and grinding, submitting to the steam from boiling acetic acid from three to ten hours, and boiling in acetic acid from three to five hours, while stirring, to dissolve out the lead sulphate and the silver and gold sulphates and chlorides. The bath is then allowed to cool to slightly below the boiling point, the solid matter settling out and being separately treated. The gold and silver are deposited from the solution, using lead electrodes.

360,852, April 12, 1887, Henry Renner Cassel, of New York, N. Y., assignor to the Cassel Gold Extracting Company (Ltd.), of Glasgow, Scotland.

Treats refractory pyritic gold ores with electrolytic chlorine and oxygen. The apparatus is a rotary drum of wood, or metal lined with insulation. It contains a series of carbon-rod anodes extending from end to end or may be lined with carbon-plate anodes. The drum is mounted upon a hollow perforated shaft of copper or iron, closely surrounded by a tubular diaphragm of asbestos cloth. The shaft extends at its ends into external vertical tanks, which are connected by an outside pipe. The drum is filled to a point above the shaft with a sodium chloride solution, and is charged with the pulverized ores. Current is supplied and as the drum rotates the metals are dissolved and deposited within the shaft and upon a metal screw conveyor therein in the form of a black slime, which is conveyed into one of the external tanks. The solution circulates freely between the tanks and through the drum.

360,853, April 12, 1887, H. R. Cassel, assignor to the Cassel Gold Extracting Company (Ltd.), of Glasgow, Scotland.

Apparatus for treating gold ores with electrolytic chlorine and oxygen from a sodium chloride solution. The apparatus is a rotary drum of wood or metal lined with insulation. This drum contains a circular series of carbon-rod anodes, extending horizontally through the ends of the drum, or may be lined with carbon or graphite anode plates. The ends of the drum contain large openings, receiving flaring metal casings constituting extensions of the drum shafts. The openings contain asbestos-cloth diaphragms. The ends of the shafts pass through stuffing boxes and extend into and open within hollow standards serving as tanks. The metal casings, shafts and tanks constitute the cathode compartments. One casing has a gas-vent opening, normally closed by a spring-actuated valve. This valve is automatically opened by a cam as it rises above the liquid level to permit the gases to escape. In use the drum

is filled to or above the level of the shaft with a sodium chloride solution and is charged with the pulverized ores. Current being supplied, the metal dissolves, the solution passes through the diaphragms, and the metal is deposited within the trunnions and tanks as a black slime.

## BOOK REVIEWS.

**Practical Alloying.** A compendium of alloys and processes for brass foundries, metal workers and engineers. By **John F. Buchanan.** Octavo, 205 pages, 41 illus. Price, \$2.50. Cleveland, Ohio: The Penton Publishing Company.

The bulk of the matter in this book appeared in *The Foundry* and other trade magazines. A long chapter on Metal Refining (in which term the author says he means to include reducing the metals from their ores) is picturesque writing, but neither very instructive nor accurate. The next, on History and Peculiarities of Alloys, is similar, only more so; it contains several absurdities. After this bad beginning the author settles down to business, commences to talk about matters with which he is familiar and redeems himself in a dozen chapters containing a large amount of valuable first-hand information. Many good photographs, on plate paper, add to the attractiveness of the work. The proposition to designate alloys is worth mentioning: Brass (copper, 60; zinc, 40) would be expressed as Cu-Zn (60-40) thus separating the numerals from the symbols and avoiding all confusion with the ordinary chemical formulas, such as  $Cu_2Zn$ ; plumbers' solder would be Pb-Sn (2-1); silicon bronze, Cu-Sn-Si (90-8-2), etc.

We recommend the book as being very practical and well written except where too flowery. Everyone having anything to do with alloys—makers, users or students—will find it worth buying.

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**A Course in Qualitative Chemical Analysis.** By **Charles Baskerville, Ph.D., and L. J. Curtman, Ph.D.** 8vo, no illustrations, 200 pages. Price, \$1.40 net. New York: The Macmillan Company.

**Qualitative Chemical Analysis, from the Standpoint of Solubilities, Ionization and Mass Action.** By **J. I. D. Hinds, Ph.D., L.L.D.** 8vo, no illustrations, 265 pages. Price, \$2. Easton, Pa.: The Chemical Publishing Company.

**Qualitative Chemical Analysis.** A laboratory guide. By **W. W. Scott, A. M.** 8vo, 31 illustrations of apparatus, 1 spectrum plate, 165 pages. Price, \$1.50 net. New York: D. VanNostrand Company.

The above books, almost alike in size and scope, are yet somewhat different in treatment.

Professor Baskerville and Dr. Curtman are connected with the College of the City of New York. Their book is clear, systematic and full of bright suggestions; it extends only to the common bases and acids; numerous "notes" will be very helpful to the students. The book is well suited for a short course in a college laboratory.

Dr. Hinds is professor at the University of Nashville. His is typographically the best of the three books. The great prominence given the terminology of the ionization theory in this book is, in the reviewer's opinion, a hindrance rather than a help to the beginner trying to learn the elementary facts of qualitative analysis. If a student reported that a white powder given him for analysis contained "lead ions" and "NO<sub>3</sub>" ions he would be reporting according to Dr. Hind's scheme, but hardly in accordance with the facts.

Mr. Scott is chief chemist of the Baldwin Locomotive Works, and his book is the most businesslike of the three. The contents cover almost the same extent of ground as the other two, but in a more practical fashion than either, and without the "ionic" form of expression of the second. It is well and forcibly written.